BOMBAY PORT TRUST.

PAPERS ON

INDIAN GRANITES.

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THE
TIMES PRESS
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Bombay Port Trust.

PAPERS ON INDIAN GRANITES.

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Bombay Port Trust.

INDIAN GRANITES.

INTRODUCTION.

The granite used in the entrances of the Prince's and Victoria Wet Docks and Merewether Dry Dock was imported from Great Britain at a cost of from Rs. 6-9-0 to Rs. 8-7-0 per cubic foot. Knowing that good granite is obtainable in the southern portion of the Presidency, I set on foot enquiries with a view to ascertain if the local supplies could not be utilised for the new docks now under construction, for which a very large quantity (upwards of 60,000 cubic feet) of dressed granite will be required. By the courtesy of the late Mr. J. N. Tata samples were obtained of the granite from Raichur used in the main staircase of the Taj Mahal Hotel, and attention was also directed to Khanapur in the Belgaum Collectorate, Karwar, Mangalore and Goa as possible sources of supply. From preliminary enquiries as to prices, it appeared possible that if the stone from these localities stood the test of examination and proved suitable for all the purposes for which granite is specified, a saving of nearly Rs. 2,00,000 would be effected on the estimates for the new docks.

The Board consequently decided to depute the Chief Engineer, Mr. P. G. Messent, M.Inst.C.E., to visit the quarries and institute further enquiries as regards cost of quarrying, carriage, dressing, &c., and to submit samples of the stone for expert opinion as to its quality and suitability in comparison with English and Scotch granites. Enquiries were also addressed to the Secretary to Government, Public Works Department, Madras, and subsequently to the Resident at Hyderabad as regards the granite quarries in the Madras Presidency and H. H. the Nizam's territories.

The reports of the experts show that the Indian samples are, with one or two exceptions, equal to or better than standard samples of Aberdeen, Cornish and Norwegian granites in respect of their compressive strength, resistance to abrasion, absorbtion of water and freedom from voids, and that they successfully resisted corrosion tests of a somewhat severe kind. The verdict is in fact altogether favorable to the use of Indian granite for purposes for which imported granite has hitherto been deemed alone suited.

The results of the investigation form a valuable contribution to the knowledge of Indian granites, and the Trustees have decided to print the papers complete as a permanent record for future use.

W. C. HUGHES, C.I.E.,

BOMBAY, 10*th June* 1905. *Chairman.*

BOMBAY PORT TRUST.

ENGINEER'S OFFICE,
BOMBAY, 6*th April* 1904.

To

THE SECRETARY,
BOMBAY PORT TRUST.

SIR,

Trustees' Resolution No. 31 *of* 19*th January* 1904.

I have the honour to report that I have visited the granite quarries at * Karwar, Khanapur, Nagargalli, Munirabad and Raichur, and also the Port of Marmagao.

2. In all cases except at Karwar the rock is more or less foliated and appears to be gneiss rather than granite. Nature of Stone.

3. The following are the particulars of the different places I visited :— Description of Places.

Karwar, in the Collectorate of North Kanara, is about 284 miles from Bombay, and has a fine natural harbour with good anchorage in 22 feet at low water. It has a masonry quay about 900 feet long with a screw pile jetty 89′ × 91′ projecting from it. At the end of the jetty there is 5 feet of water at L. W. S. T., and this depth could be easily increased two or three feet. There are three old hand cranes of small power on the jetty and one on the quay. Messrs. Shepherd & Co.'s steamers call twice a week on their way to and from Bombay. Granite is found in boulders sometimes surrounded by moorum on the Hydrahat range of hills extending from Karwar southwards about 48 miles. The stone varies a great deal in quality, some of it being partly decomposed. It does not seem to be systematically quarried at any particular place, but selected boulders here and there on the hill side are drilled and blasted, and the stone slid down to the foot of the hill. Some good stone is now being got within half a mile of the jetty. The main roads are good. The average rainfall is 118″. Labour is scarce and poor. Government charge a royalty of 4 annas per 100 cubic feet.

Khanapur, in the Belgaum Collectorate, is on the Southern Mahratta Railway. It is 380 miles from Bombay by rail and 102¾ miles from Marmagao. There are quarries on the south side of the river Malaprabha, the one which I visited being about two miles from the station along the Belgaum road. Large slabs from 6″ to 9″ thick are obtained by heating with fire the upper surface of the rock. Labour is plentiful and the *Wadars*, a wandering tribe, are expert quarrymen after their own methods. Some use fire and some wedges, but none, I believe, use both. The main roads are good, and as the rainfall only averages 43″, the quarries might be partially worked in the monsoon. The royalty charged by Government is 8 annas per 100 cubic feet.

Nagargalli, on the Southern Mahratta Railway, 409 miles by rail from Bombay and 97¾ miles from Marmagao, is in the Belgaum Collectorate. About 2 miles east of the station there are several quarries which were largely used when the railway was under construction. As there are no good roads to them it will be necessary to make roads or lay a siding. The latter

* These places are shown on accompanying map (see page 13).

would probably be cheapest in the end, as the banks of old sidings still exist and require very little repair. Labour is good and easily procured. As there is a heavy rainfall, 150″, no work could be done in the monsoon. The Government royalty is 8 annas per 100 cubic feet.

Munirabad, on the Southern Mahratta Railway, 538½ miles by rail from Bombay and 227¼ miles from Marmagao, is in the Nizam's Dominions. From the quarries in the hills about 3 miles north of the station both red and grey granite or gneiss can be obtained. The stone was much used during the construction of the line about 18 years ago, and judging from the piers of the bridge over the Tungabudhra river which I examined has stood well. The bed stones for the large bridge over the Godaveri were obtained from these quarries. It is said that stones of any size can be got by wedging. There are no good roads but a siding could be cheaply laid, as the bank of the old siding used during construction still remains in fair condition. Good labour can be readily obtained. Work could be carried on during the monsoon, as the rainfall averages only about 20″. I have not yet heard the exact amount of royalty asked for, but I understand the charge is a nominal one only.

Raichur, on the south-east branch of the Great Indian Peninsula Railway, 443 miles from Bombay, is in the Nizam's Dominions. There are several small quarries both in and near the town from which stone of a dark grey colour is obtained both by means of fire and of wedges. It is found both in boulders and in beds. In the latter case lamination is often very clearly defined. It would probably be difficult to get stones of any great thickness. The roads are bad. The rainfall is only slight. Good labour is procurable in the neighbourhood. I have not yet heard what royalty is charged by the Nizam's Government, but I understand it is merely nominal.

Marmagao, in Portuguese India, is the terminal port of the Western India Portuguese Railway and is about 242 miles by sea from Bombay. The harbour, a small one, is protected by a short breakwater lying in the direction N 14°, W. It has a quay 1,200 feet long with 24 feet of water at low water. One 20-ton and six 30-cwt. steam cranes are provided, and also transit sheds and railway sidings. This port offers an alternative route by sea to Bombay from the three stations on the Southern Mahratta Railway mentioned above. Messrs. Shepherd & Co., who own the only line of steamers calling regularly, quote the prohibitive rate of Rs. 10 per ton including cranage, but not wharfage at both ports. It would probably be possible to charter a suitable steamer from time to time at about a third of that rate.

Best Quarries.

4. I consider that if the expert to whom the samples have been submitted consider the granite or gneiss of suitable quality, stones of sufficient size for the most of the granite work in the entrances could be obtained from Nagargalli and Munirabad if the quarries were properly opened up and worked. The above two quarries seem to me the most suitable and convenient of all I have seen.

The Cost of the Stone.

5. The cost of getting and dressing the stone will be identical at Nagargalli and Munirabad, as the same class of labour is available. For the sake of comparison I have estimated the cost of two typical stones with the maximum and minimum of work on them. One a hollow quoin measuring 78·8 cubic feet (5·8 tons) fine dressed to curved templates on the face and

the other an ordinary coping measuring 18 cubic feet (1·33 tons) medium dressed on top, bed and face. The following are the estimates per cubic foot for Munirabad stone :—

	Hollow quoin.			Coping.		
	Rs.	a.	p.	Rs.	a.	p.
1. Quarrying, &c.	1	0	0	1	0	0
2. Dressing	3	0	0	1	2	0
3. Transport to site of work	0	15	0	0	15	0
4. Setting	0	10	0	0	8	0
	5	9	0	3	9	0
Contingencies, &c.	0	9	0	0	6	0
	6	2	0	3	15	0
Estimated cost of English granite	9	6	0	6	10	0
Saving ... ... Rs.	3	4	0	2	11	0
	34·6 p. cent.			40·5 p. cent.		

Taking the minimum rate of $\frac{1}{10}$th of a maund per mile for railway freight, the cost of Nagargalli stone will be 1 anna 8 pies per cubic foot less.

Comparison of Total Cost.

6. The total quantity of granite required in the entrance of the Wet and Dry Docks is 59,749 cubic feet. If Indian granite could be used for all of this, the saving would be about Rs. 1,85,000. I am afraid however it will be difficult or inadvisable to get the following stones in India for reasons given opposite each :—

Heel stone...	Depth (4′ 0″) and weight.
Hollow quoin stone	Difficult dressing.
Pointing sills	Depth (4′ 6″).

The total amount of these stones is 20,718 cubic feet or rather more than one-third of the total quantity of granite. The final decision as to how far Indian granite can be substituted for English will, of course, have to be deferred until the expert's opinion on the samples submitted is received. The question of using Indian granite for the ordinary coping depends on the price quoted for basalt coping by the Contractors. The total amount of front and back coping is nearly 200,000 cubic feet, and such a large quantity could probably be obtained for a considerably less rate than that quoted above.

7. The Chief Engineers of the Great Indian Peninsula and Madras Railways very kindly gave me information about the granite quarries near their railways, and I enclose copies of their letters. The Chief Engineer, Southern Mahratta Railway, was good enough to show me himself the best quarries on his line, and give me verbally all particulars about them.

8. I am forwarding herewith a map showing the places mentioned in this report. (See page 13.)

I have, &c.,
P. GLYNN MESSENT,
Engineer on Special Duty.

GREAT INDIAN PENINSULA RAILWAY COMPANY.

CHIEF ENGINEER'S OFFICE,
BOMBAY, 13*th February* 1904.

No. 2449.

To

P. GLYNN MESSENT, ESQ.

SIR,

Your No. 124/107 *of* 13*th January—Granite on the G. I. P. Railway.*

With reference to the enquiry contained in para. 2 of your letter, I have to inform you that the District Engineer, South-East Line, writes as follows :—

"I have had the correspondence about granite looked up, but can only find some relating to "broken granite stone ballast.

"2. There is a rate of Rs. 225 per 100 c.ft. for bed blocks of granite.

"3. Granite is employed in abutments of the 3-30 feet skew girder bridge at 120-70-84 "(rebuilt about 1875) and has stood very well.

"4. When I was on the survey of the Raichur-Wandali Light Railway, I observed that "the granite varied in quality very much. Some of it appears to perish easily, while other "resisted the weather very well.

"5. Granite of good quality is obtainable quite close to Raichur station, and tenders for "rubble masonry at Rs. 24 per 100 c.ft. have been recently received.

"6. But it has been used so very little of late years on this Railway that any definite "information would probably be misleading.

"7. I send by free parcel samples of two kinds obtainable from Raichur. These are both "selected varieties.

"8. The cost at station will depend chiefly on the size of the blocks required.

"9. Before using granite on important works the question of the suitability of Raichur "granite will require very much more careful enquiry than I am in a position to give to it."

2. I send the two samples of granite referred to, and would suggest that you arrange for the stone to be examined and enquiries made on the spot. It is found close to the station exposed on the surface of the ground and in hillocks.

3. I may mention that several of our bridges at the Raichur end of the line have been built of granite and that after 35 years' exposure to the air there are as yet no signs of decay.

I have, &c.,

(Sd.) J. G. H. COLLISTER,

Chief Engineer.

MADRAS RAILWAY COMPANY.

CHIEF ENGINEER'S OFFICE,

MADRAS, 1*st March* 1904.

No. C.-166—4244.

From

THE CHIEF ENGINEER,

MADRAS RAILWAY COMPANY,

To

THE ENGINEER ON SPECIAL DUTY,

BOMBAY PORT TRUST,

Bombay.

SIR,

With reference to your letter No. 125/107 of 13th ultimo, I have the honour to forward herewith a statement showing the quarries where granite stone is available and the other particulars required by you.

I have, &c.,

(Sd.) A. B. STRANGE,

for Ag. Chief Engineer.

MADRAS RAILWAY COMPANY.

ENGINEERING DEPARTMENT, 3RD DISTRICT, N.-W. LINE.

STATEMENT showing names of Quarries in 3rd District where Granite Stone is available.

Name of Quarry.	Nearest station and distance from same.	Can large blocks be obtained.	Is there considerable quantity in the quarry.	Cost per c. ft. delivered at station.	Cost per c. ft. at quarry.	REMARKS.
Mynapuram ...	Gooty, 3 miles ...	Only sizes suitable for buildings.	Yes	Rs. 0 3 9	Rs. 0 3 3	
Yengilibunda ...	Jekalcheru ...	Do. do. ...	Yes	„ 0 3 6	„ 0 3 0	
Kupgal Quarry ...	Kupgal, 2 miles ...	Yes	Yes	Block of 2 ft. Rs. 0 9 0 to „ 0 10 0	Block of 2 ft. Rs. 0 8 0 Large size. Rs. 0 12 0 to „ 1 0 0	Large blocks only.
Kondapuram Gutta	Adoni, 3½ miles ...	Difficult to get large blocks.	Yes	Rs. 0 1 0	Rs. 0 0 8	Building stones.
Thuddu Konda ...	Kosgi, 3 „ ...	Yes	Yes	„ 0 1 9	„ 0 1 6	Large slabs, vary in price.
Yendapally ...	Kosgi, 2 „ ...	Yes	Yes	„ 0 1 8	„ 0 1 5	Do. do.
Chenal Gutta ...	Raichur, 3 „ ...	Yes	Yes	„ 0 2 6	„ 0 2 3	Large slabs, will cost more.
Osoor ...	Raichur, 1 mile ...	Yes	Yes	„ 0 2 0	„ 0 1 9	Do. do.

BOMBAY PORT TRUST.

ENGINEER'S OFFICE,
BOMBAY, 23*rd August* 1904.

No. 2699-107.

To

THE SECRETARY,
BOMBAY PORT TRUST.

Trustees' Resolution No. 31 *of* 19*th January* 1904.

SIR,

I have the honour to report that since writing my No. 1084/107 of 6th April 1904, I have visited granite quarries at Pallaveram, Sivapuram and Godhra.*

2. The following are the particulars of the different places :—

Pallaveram is on S. I. Ry., about 11 miles from Madras. The quarries now being worked by the Indian Granite Company are within a mile of the station. They are at present worked principally for setts and metal. The rock is dark in colour and composed of hypersthene microcline quartz and accessory iron ores. It was named in 1893 Charnockite, as it was found to have been used for the tombstone of Job Charnock, the founder of Calcutta. The stone could be sent by either rail or road to Madras from where it could be despatched to Bombay (794 miles) by train or steamer.

See page 134, Memoirs of the Geological Survey of India, Vol. XXVIII, Part 2.

Sivapuram is three miles north of Munirabad station on the S. M. Ry., under which name I mentioned this quarry in my former report. On my first visit I had not time to go right up to the quarries, but on this occasion I went and examined them carefully. There is any quantity of stone both in large boulders and solid rock, and stones of any size could be got. I also visited the ruined city of Hampe, in the construction of which about 650 years ago this stone was extensively used. I examined several buildings and could find no signs at all of the deterioration or disintegration in the stone.

See pages 53 and 200 of Memoirs of the Geological Survey of India, Vol. XXV.

Godhra on B. B. & C. I. Ry., 292 miles from Bombay, is in the Panch Mahals Collectorate. About 2 miles this side of Godhra there are a large number of granite boulders along the banks of the River Mesri. The stone varies very much in quality, some being quite rotten. The natives of the district do not know how to quarry or dress it, and as far as I could learn it has never been used in any buildings. Some boulders were broken up for metal during the construction of the Baroda-Godhra Chord line. The average rainfall is about 30″.

3. I have received the results of the crushing and absorption test of the samples I sent home, but not those of the microscopical and other tests. As soon as I receive those I will send in my final report.

I have, &c.,
P. GLYNN MESSENT,
Chief Engineer.

* These places are shown on accompanying map (see page 13).

BOMBAY PORT TRUST.

ENGINEER'S OFFICE,

BOMBAY, *3rd November* 1904.

No. 3505-107.

To

THE SECRETARY,

BOMBAY PORT TRUST.

SIR,

Trustees' Resolution No. 31 *of* 19*th January* 1904.

I have the honor to forward herewith Mr. Bertram Blount's report upon certain samples of Indian granite, received with the Consulting Engineer's letter of 23rd September 1904.

2. The samples have been most thoroughly examined and tested, and the report very carefully considered. Mr. Blount has placed the samples in the following orders :—

1.	Raichur	...	...	...	Sample	C.
2.	,,	...	...	...	,,	B.
3.	,,	...	...	...	,,	A.
	Munirabad	...	...	...	,,	B.
4.	Khanapur	...	...	...	,,	A.
	,,	...	...	...	,,	B.
5.	Karwar...	...	...	...	,,	A.
6.	Munirabad	...	...	...	,,	A.
	Nagargalli	...	...	...		...
7.	Sivapuram	...	...	...		...
8.	Karwar...	...	...	...	,,	B.

I may say that the sample placed seventh, which was wrongly labelled Harihar, is really from Sivapuram, about three miles from Munirabad station, from the same quarry as the samples obtained from Munirabad.

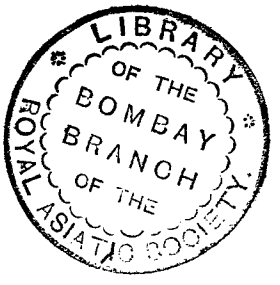
3. If the Trustees decide to use Indian granite, I think it should be from Raichur or Munirabad, as no stones thicker than 9″ can be obtained from the Khanapur quarries which are placed next in order of merit.

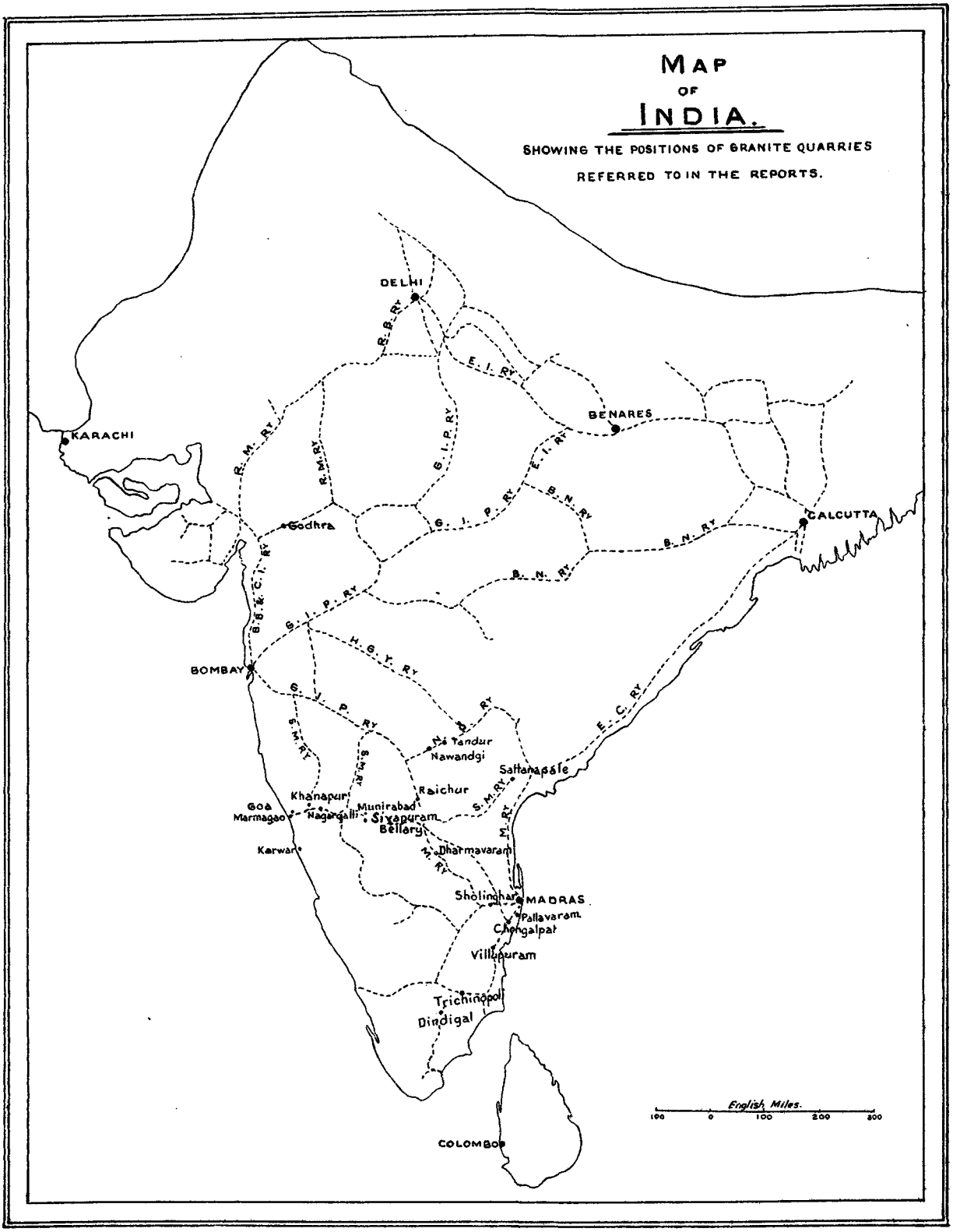
4. As the report of the granites mentioned above is so good, I would beg to recommend that it be used for all the items in schedule for which granite is specified with certain exceptions mentioned below. The total amount required will be about 37,000 c.ft. The Contractors might now be asked to quote rates for Indian granites for these items as provided for in Clause 14 of the Specification. They might also be asked to quote rates for front and back copings, of which there are about 200,000 c.ft., as granite would be preferable to blue basalt if the price were the same or even a little more.

5. The following stones should, in my opinion, be of British granite on account of their size and the necessity for very careful dressing, pointing sills, hollow quoins, anchor and heel stones.

6. I have added the order of merit and the distances from Bombay to Mr. Blount's abstract, (see page 65) and am having copies lithographed. I will forward 15 copies for the use of the Trustees as soon as I receive them.

I have, &c.,
P. GLYNN MESSENT,
Chief Engineer.





TIMES PRESS, BOMBAY.

7 The Sanctuary,
Westminster, S.W.,
23rd September 1904.

1 Enclosure.

The CHIEF ENGINEER,
Bombay Port Trust,
Ballard Road, Bombay.

Sir,

Granite for New Docks.

We have just received and have the pleasure to forward herewith, Mr. B. Blount's report on his examination of all the samples of Indian Granite received from you, with the exception of the last lot received, *viz.*, "Godhra" granite, which is at the works of Messrs. Kirkaldy & Son, undergoing similar tests and analyses.

As this report has only just been received, by hand, we have been unable to study it, and cannot, therefore, offer any remarks thereon by this mail. Mr. Blount has promised us a duplicate copy for our own use, which we shall peruse, with interest, when received.

We have, etc.,
(Sd.) Sir J. WOLFE BARRY & A. J. BARRY.

76 & 78, York Street, Westminster,

London, S. W., 22*nd September* 1904.

No. 301 of 1904.

To

Messrs. David Kirkaldy & Son,

99, Southwark Street, S. E.

Investigation *re* Granite.

Dear Sirs,

In accordance with your instructions I have made a full examination of 12 samples of Indian granite and have compared them with samples of Cornish, Scottish and Norwegian granite.

In this report for the sake of clearness each sample is considered separately and, in order that a ready and concise mode of comparison may be available, tables have been prepared in which the whole of the data are set out side by side.

A. Granites in General Use.

Aberdeen Granite.

Chemical Composition.

	Per cent.
Silica (SiO_2)...	72·60
Titanic acid (TiO_2)	Trace.
Alumina (Al_2O_3)	13·80
Ferric oxide (Fe_2O_3)	2·44
Ferrous oxide (FeO)	0·83
Lime (CaO)...	1·38
Magnesia (MgO)	0·34
Potash (K_2O)	3·71
Soda (Na_2O)	3·98
Combined water and loss	0·92
	100·00

Mechanical Tests.

Resistance to Thrusting Stress.—The results of the compressive test made by yourselves are as follows :—

Test No.	Base Area.	Crushed. Tons per q. ft.
M. M. 3341	11·22 sq. in.	1,800

Resistance to Abrasion.—The method adopted for this test on this and the remaining samples was as follows :—Cubes were cut of approximately 1 inch side and were rumbled in a mill with flint pebbles until the angles had been rounded. They were then weighed and again rumbled for 2 hours. The loss of weight was ascertained and is stated in terms of the weight of the sample after the first treatment. The object of the preliminary rumbling was to remove sharp angles which might be chipped and cause a larger loss of weight than that properly due to the wear of the stone.

The percentage of loss ascertained in this way was

2·85 per cent.

Specific Gravity.

The specific gravity of the stone in its natural state and after it had been powdered was determined—

Specific gravity in block ... ... 2·634
Specific gravity in powder ... 2·640

Volume of voids **0·23** per cent. of volume of stone.

Absorption of Water.

The percentage of water absorbed by the sample was determined and found to be

0·16 per cent.

Resistance to Weathering and Corrosion.

Freezing Tests.—Test pieces having both rough and polished surfaces were exposed to a temperature below freezing and were then thawed. The operation was repeated, so that in all ten alternations were made.

Wet.	Dry.
Sample unaffected.	Sample unaffected.

Corrosion Tests.—Similar test pieces were exposed to the action of sulphurous acid for 5 days in order to simulate the influence of the air of large towns using coal as a fuel. As in the previous case wet and dry tests were made.

Wet, 5 days.	Dry, 5 days.
Sample unaffected.	Sample unaffected.

A more severe test was made by subjecting the specimen to the action of hydrochloric acid (10 per cent. H. Cl.) for 14 days.

Ferruginous constituents slightly attacked ; colour somewhat lighter.

Structure.

The structure of a granite is at least as important as its composition. Sections of the sample were cut and examined with ordinary light both reflected and transmitted and with polarised light. Photographs with transmitted and polarised light have been prepared and are appended. To each has been attached a brief description of the chief minerals present. It must be understood that no single section of practicable dimensions can exhibit all the constituents of a rock so complex as a granite; the sections merely show the principal substances. In each case the amplification has been chosen consistently with the size of the crystals. In the present instance a magnification of 60 diameters has been used.

The structure of the Aberdeen granite now under discussion is as follows. The constitual crystals are comparatively coarse. There is a normal proportion of quartz, felspar and mica. The quartz is somewhat granular; the felspar is chiefly of the orthoclase type and is only moderately decomposed. Both kinds of mica, muscovite or white mica and biotite or dark mica, are present. Accessory minerals, *e.g.*, chlorite, occur but not in important quantity. The general appearance of a section of the sample is shown in the appended photographs, allowance being made for the fact that it is impracticable to exhibit every mineralogical individual in a single section of moderate dimensions.

Cornish Granite.

	Per cent.
Silica (SiO_2)	71·50
Titanic acid (TiO_2)	Trace.
Alumina (Al_2O_3)	16·46
Ferric oxide (Fe_2O_3)	0·59
Ferrous oxide (FeO)	1·27
Lime (CaO)	0·92
Magnesia (MgO)	0·40
Potash (K_2O)	4·20
Soda (Na_2O)	3·55
Combined water and loss	1·11
	100·00

Mechanical Tests.

Resistance to Thrusting Stress.—The results of the compressive test made by yourselves are as follows:—

Test No.	Base Area.	Crushed. Tons per sq. ft.
M. M. 3340	8·04 Sq. in.	1,402

Resistance to Abrasion.—The percentage of loss ascertained in the manner described above (page 18) was

5·95 per cent.

Specific Gravity.

The specific gravity of the stone in its natural state and after it had been powdered was determined—

Specific gravity in block ... ... 2·639
Specific gravity in powder ... ... 2·650

Volume of voids **0·42** per cent. of volume of stone.

Absorption of Water.

The percentage of water absorbed by the sample was determined and found to be

0·41 per cent.

Resistance to Weathering and Corrosion.

Freezing Tests.—(See page 18). The test pieces were subjected to 10 alternations of frost and thaw—

Wet.	Dry.
Sample unaffected.	Sample unaffected.

Corrosion Tests.—(See page 18). The test pieces were exposed to the action of sulphurous acid for 5 days—

Wet, 5 days.	Dry, 5 days.
Sample unaffected.	Sample unaffected.

A more severe test was made by subjecting the specimen to the action of hydrochloric acid (10 per cent. H. Cl) for 14 days.

Ferruginous constituents slightly attacked ; colour somewhat lighter.

Structure.

The stone consists chiefly of quartz, orthoclase and biotite. The orthoclase is considerably altered. There is some muscovite and a small amount of plagioclase (soda felspar). The crystals are large and the felspar is somewhat decomposed. Accessory constituents, such as magnetite and epidote are present. In the section photographed the predominant constituent is orthoclase, much of it altered by decomposition. There are also large patches of quartz and both varieties of mica (biotite and muscovite).

Norwegian Granite.

Chemical Composition.

	Per cent.
Silica (SiO_2)	70·78
Titanic Acid (TiO_2)	0·11
Alumina (Al_2O_3)	15·27
Ferric Oxide (Fe_2O_3)	2·01
Ferrous Oxide (FeO)	1·00
Lime (CaO)	1·82
Magnesia (MgO)	0·97
Potash (K_2O)	3·59
Soda (Na_2O)	3·57
Combined water and loss	0·88
	100·00

Mechanical Tests.

Resistance to Thrusting Stress.—The results of the compressive test made by yourselves are as follows :—

Test No.	Base Area.	Crushed. Tons per sq. ft.
M. M. 3942	8·41 sq. in.	1,870

Resistance to Abrasion.—The percentage of loss ascertained in the manner described above (page 18) was

1·80 per cent.

Specific Gravity. The specific gravity of the stone in its natural state and after it had been powdered was determined—

Specific gravity in block	2·666
Specific gravity in powder... ...	2·656
Volume of voids	*Nil.*

Absorption of Water. The percentage of water absorbed by the sample was determined and found to be

0·34 per cent.

Resistance to Weathering and Corrosion. **Freezing Tests.**—(See page 18). The test pieces were subjected to 10 alternations of frost and thaw—

Wet.	Dry.
Sample unaffected.	Sample unaffected.

Corrosion Tests.—(See page 18). The test pieces were exposed to the action of sulphurous acid for 5 days.

Wet, 5 days.	Dry, 5 days.
Sample unaffected.	Sample unaffected.

A more severe test was made by subjecting the specimen to the action of hydrochloric acid (10 per cent. H Cl.) for 14 days.

Ferruginous constituents slightly attacked : Colour somewhat lighter.

Structure. The stone consists of quartz, biotite and both orthoclase and plagioclase. There is some magnetite, and in places granules of quartz are embedded in the felspar.

GENERAL CHARACTERISTICS OF STANDARD SAMPLES.

The three samples, all differring in origin, which have been chosen as representing building granites of known good quality present certain similarities. Their composition shows that a great part of the felspar present is a potash felspar (orthoclase or microcline) ; it is generally accepted that potash felspar is more resistant than soda felspar (plagioclase) to weathering. The specific gra-

vities before and after powdering show no great difference and the weight of water absorbed is in all cases small. The compressive strength of the Scottish and Norwegian samples is fairly high, and the resistance to abrasion good. Their structure is fairly uniform and the felspar is only slightly decomposed. The Cornish granite on the other hand has a comparatively low compressive strength and is less resistant to abrasion than the two other specimens. Its structure is coarse and the felspar is more decomposed. As might be predicted it can be more readily cut and worked. Seeing that although a softer and less refractory material than the granites from Scotland and Norway, it is nevertheless a useful structural material, the conclusion may fairly be drawn that similar qualities in the samples now to be considered will not prevent their utilisation ; in short the examination of this Cornish sample allows a wider choice among the Indian specimens.

B. Indian Granites.

These may be conveniently considered in groups according to their place of origin. The first group is that taken from quarries at or near Raichur :—

RAICHUR.

Chemical Composition.

	Sample No. 1.	Sample No. 2.	Sample No. 3.
	A	B	C
		From quarry 1 mile from Raichur Station (E).	From quarry 3 miles from Raichur Station (N-E).
	Per cent.	Per cent.	Per cent.
Silica (SiO_2)	72·24	70·36	72·30
Titanic Acid (TiO_2)	Trace	Trace.	Trace.
Alumina (Al_2O_3)	15·72	17·02	15·32
Ferric Oxide (Fe_2O_3) ...	0·75	0·86	2·21
Ferrous Oxide (FeO)	0·87	1·03	0·31
Lime (CaO)	1·08	1·89	1·54
Magnesia (MgO)	0·61	0·56	0·40
Potash (K_2O)	3·15	3·14	3·21
Soda (Na_2O)	4·80	4·49	4·66
Combined water and loss ...	0·78	0·74	0·05
	100·00	100·00	100·00

Mechanical Tests.

Resistance to Thrusting Stress.—The results of the compressive tests made by yourselves are as follows:—

Test No.	Base Area.	Crushed. Tons per sq. foot.
M.M. 1565 ...	15·21 sq. in.	2,427
„ 1566 ...	15·01 „ „	2,085
„ 1567 ...	14·90 „ „	2,444

Resistance to Abrasion.—The percentages of loss ascertained in the manner described above (page 18) were:—

	No. 1.	No. 2.	No. 3.
	Per cent.	Per cent.	Per cent.
Loss by abrasion	3·27	2·91	2·20

Specific Gravity.

The specific gravities of the stones in their natural state and after they had been powdered were determined.

	No. 1.	No. 2.	No. 3.
* Specific gravity in block ...	2·652	2·661	2·650
* Specific gravity in powder ...	2·653	2·661	2·648
Volume of void	*Nil.*	*Nil.*	*Nil.*

* The numbers are so nearly identical as to fall practically within the limits of experimental error.

Absorption of Water.

The percentage of water absorbed by the samples was determined and found to be—

	No. 1.	No. 2.	No. 3.
	Per cent.	Per cent.	Per cent.
Water absorbed.	0·13	0·07	0·05

Freezing Tests.—(See page 18.) The tests pieces were subjected to 10 alternations of frost and thaw— **Resistance to Weathering & Corrosion.**

	Wet.	Dry.
No. 1	Sample unaffected.	Sample unaffected.
No. 2	do.	do.
No. 3	do.	do.

Corrosion Tests.—(See page 18.) The test pieces were exposed to the action of sulphurous acid for 5 days.

	Wet.	Dry.
No. 1	Sample unaffected.	Sample unaffected.
No. 2	do.	do.
No. 3	do.	do.

A more severe test was made by subjecting the specimens to the action of hydrochloric acid (10 per cent. H Cl) for 14 days.

No. 1 ...Ferruginous constituents slightly attacked; colour somewhat lighter.
No. 2 ... Do. do.
No. 3 ... Do. do.

Structure.

Sample No. 1 is of moderately coarse structure and consists of both orthoclase and plagioclase felspars, quartz and dark mica (biotite). The orthoclase and the biotite are considerably altered. Accessory constituents such as epidote, chlorite, apatite and magnetite are present. In places pyrites occurs.

Sample No. 2 is generally similar in structure to No. 1. There are present both classes of felspar and the mica is biotite. Isolated grains of sphene are discernible, no pyrites was detected. The felspar is considerably altered.

Sample No. 3, though resembling Nos. 1 and 2 and like those consisting of quartz, orthoclase, plagioclase and biotite with such accessory constituents as chlorite and magnetite, differs from the others in showing less alteration of the felspar. In this respect it is to be preferred to its companions.

The second group of Indian granites is from Munirabad. Two samples were examined. The numbers run consecutively with those already used.

Chemical Composition.

MUNIRABAD.

	Sample No. 4.	Sample No. 5.
	A.	**B.**
	Per cent.	Per cent.
Silica (SiO_2)	72·64	74·22
Titanic Acid (TiO_2)	0·08	Trace
Alumina (Al_2O_3)	14·54	14·44
Ferric Oxide (Fe_2O_3)	1·19	1·21
Ferrous Oxide (FeO)	0·48	0·46
Lime (CaO)	1·98	1·20
Magnesia (MgO)	0·38	0·34
Potash (K_2O)	3·37	2·96
Soda (Na_2O)	4·49	4·57
Combined water and loss	0·85	0·60
	100·00	100·00

Mechanical Tests.

Resistance to Thrusting Stress.—The results of the compressive tests made by yourselves are as follows:—

Test No.	Base Area.	Crushed. Tons per sq. ft.
M.M. 1568	15·13 Sq. In.	1,808
,, 1569	15·33 ,,	2,048

Resistance to Abrasion.—The percentages of loss ascertained in the manner described above (page 18) were—

	No. 4.	No. 5.
	Per cent.	Per cent.
Loss by abrasion	3·49	1·92

The specific gravities of the stones in their natural state and after they had been powdered were determined— **Specific Gravity.**

	No. 4.	No. 5.
Specific gravity in block	2·630	2·630
Specific gravity in powder... ...	2·640	2·629
Volume of voids	0·38%	*Nil.*

The percentage of water absorbed by the samples was determined and found to be— **Absorption of Water.**

	No. 4.	No. 5.
	Per cent.	Per cent.
Water absorbed	0·24	0·17

Freezing Tests.—(See page 18.) The test pieces were subjected to 10 alternations of frost and thaw— **Resistance to Weathering and Corrosion.**

	Wet.	Dry.
No. 4	Sample unaffected.	Sample unaffected.
No. 5	do.	do.

Corrosion Tests.—(See page 18.) The test pieces were exposed to the action of sulphurous acid for 5 days—

	Wet.	Dry.
No. 4	Sample unaffected.	Sample unaffected.
No. 5	do.	do.

A more severe test was made by subjecting the specimens to the action of hydrochloric acid (10 per cent. H Cl) for 14 days.

No. 4 ... Ferruginous constituents slightly attacked : colour somewhat lighter.

No. 5 ... Do. do. do. do. do.

Structure. In Sample No. 4 the general structure is coarse. The felspar is slightly coloured, giving a reddish appearance to the stone. Both orthoclase and plagioclase are present and show but little alteration. The mica is biotite and in places has decomposed to form chlorite. The crystals of quartz are a good deal cracked, a fact which accounts for the compressive strength being comparatively low and the loss by abrasion somewhat high.

Sample No. 5 has a highly characteristic structure. A large proportion of the quartz is distributed as inclusions in the form of granules throughout the felspars; both potash felspars (orthoclase and microcline) and soda felspars (plagioclase) are present. The remaining constituents are biotite, chlorite, some epidote and a little magnetite. All the minerals other than quartz show signs of alteration. Except for this the granite is of satisfactory quality.

Two samples (Nos. 6 and 7) from Khanapur were examined in a similar manner.

Chemical Composition.

KHANAPUR.

—	Sample No. 6. A Per cent.	Sample No. 7. B Per cent.
Silica (SiO_2)	72·06	72·32
Titanic acid (TiO_2)	0·13	Trace.
Alumina (Al_2O_3)	14·93	15·30
Ferric Oxide (Fe_2O_3)	1·54	1·27
Ferrous Oxide (FeO)	0·21	0·55
Lime (CaO)	1·74	1·83
Magnesia (MgO)	0·37	0·38
Potash (K_2O)	3·53	3·91
Soda (Na_2O)	3·52	4·15
Combined water and loss	1·97	0·24
	100·00	100·00

Resistance to Thrusting Stress.—The results of the compressive tests made by yourselves are as follows:— **Mechanical Tests.**

Test No.	Base Area.	Crushed. Tons pen sq.foot.
M. M. 1570	15·05 sq. in.	2,484
M. M. 1571	15·29 „	2,012

Resistance to Abrasion.—The percentages of loss ascertained in the manner described above (page 18) were—

	No. 6.	No. 7.
	Per cent.	Per cent.
Loss by abrasion	3·21	2·81

The specific gravities of the stones in their natural state and after they had been powdered were determined— **Specific Gravity.**

	No. 6.	No. 7.
Specific gravity in block	2·632	2·642
Specific gravity in powder... ...	2·636	2·644
Volume of voids	0·15%	0·08%

The percentage of water absorbed by the samples was determined and found to be— **Absorption of Water.**

	No. 6.	No. 7.
	Per cent.	Per cent.
Water absorbed	0·19	0·20

Freezing Tests.—(See page 18.) The test pieces were subjected to 10 alternations of frost and thaw— **Resistance to Weathering and Corrosion.**

	Wet.	Dry.
No. 6	Sample unaffected.	Sample unaffected.
No. 7	do.	do.

Corrosion Tests.—(See page 18). The test pieces were exposed to the action of sulphurous acid for 5 days—

	Wet.	Dry.
No. 6	Sample unaffected.	Sample unaffected.
No. 7	do.	do.

A more severe test was made by subjecting the specimens to the action of hydrochloric acid (10 per cent. H Cl) for 14 days.

No. 6 ... Ferruginous constituents slightly attacked : colour somewhat lighter.

No. 7 ... Do. do. do. do. do.

Structure.

The structure of this pair of samples is similar and highly characteristic. The chief constituents are disposed in bands and the stone in this respect resembles gneiss rather than granite.

In sample 6, quartz occurs both in large crystals and small granules; both potash and soda felspars are present, not greatly altered. The mica is biotite. Chlorite exists in bands.

Sample No. 7 is composed of the same minerals ; the mica (biotite) is more abundant ; chlorite is present in bands.

In both samples the chief constituents (quartz and felspar) are a good deal cracked as if the rock had been subjected to considerable pressure subsequent to its solidification.

A single sample from Nagargali (No. 8) was examined.

NAGARGALI No. 8.

Chemical Composition.

	Per cent.
Silica (SiO_2)	71·60
Titanic Acid (TiO_2)	Trace.
Alumina (Al_2O_3)	15·68
Ferric Oxide (Fe_2O_3)	1·11
Ferrous Oxide (FeO)	1·20
Lime (CaO)	2·00
Magnesia (MgO)	0·58
Potash (K_2O)	2·10
Soda (Na_2O)	4·41
Combined water and loss	1·32
	100·00

Resistance to Thrusting Stress.—The results of the compressive test made by yourselves are as follows :— **Mechanical Tests.**

Test No.	Base Area.	Crushed. Tons per sq. foot.
M. M. 1572 ...	15·05 Sq. in. ...	1,870

Resistance to Abrasion.—The percentage of loss ascertained in the manner described above (page 18) was—

4·80 per cent.

The specific gravity of the stone in its natural state and after it had been powdered was determined. **Specific Gravity.**

Specific gravity in block	... ...	2·670
Specific gravity in powder	... ...	2·675

Volume of voids **0·19** per cent. of volume of stone.

The percentage of water absorbed by the sample was determined and found to be— **Absorption of Water.**

0·08 per cent.

Freezing Tests.—(See page 18.) The test pieces were subjected to 10 alternations of frost and thaw— **Resistance to Weathering and Corrosion.**

Wet.	Dry.
Sample unaffected.	Sample unaffected.

Corrosion Tests.—(See page 18.) The test pieces were exposed to the action of sulphurous acid for 5 days—

Wet, 5 days.	Dry, 5 days.
Sample unaffected.	Sample unaffected.

A more severe test was made by subjecting the specimen to the action of hydrochloric acid (10 per cent. H Cl) for 14 days.

Ferruginous constituents slightly attacked : colour somewhat lighter.

Structure. The point of chief interest is the broken-up condition of the quartz and felspar, the result of which is indicated by the moderate crushing stress and the somewhat high loss by abrasion. Orthoclase, microcline and plagioclase are present. The remaining constituents are biotite in large amount and chlorite in considerable quantity. In places epidote can be recognised.

A pair of samples marked Karwar (Nos. 9 and 10) were tested and analysed.

Chemical Composition.

KARWAR.

	Sample No. 9.	Sample No. 10.
	A	**B**
	Per cent.	Per cent.
Silica (SiO_2)...	73·40	72·02
Titanic Acid (TiO_2)	Trace.	Trace.
Alumina (Al_2O_3)	16·60	14·92
Ferric Oxide (Fe_2O_3)	1·37	1·69
Ferrous Oxide (FeO)	0·24	0·46
Lime (CaO)...	1·20	1·30
Magnesia (MgO)	0·23	0·35
Potash (K_2O)	3·80	3·90
Soda (Na_2O)	3·11	4·26
Combined water and loss	0·05	1·10
Total	100·00	100·00

Mechanical Tests. **Resistance to Thrusting Stress.**—The results of the compressive test made by yourselves are as follows:—

Test No.	Base Area.	Crushed. Tons per sq. foot.
M. M. 1573	15·21 sq. in.	2,271
„ 1574	15·05 „	1,303

Resistance to Abrasion.—The percentages of loss ascertained in the manner described above (page 18) were—

	No. 9.	No. 10.
	Per cent.	Per cent.
Loss by abrasion	1·95	7·24

The specific gravities of the stones in their natural state and after they had been powdered were determined— **Specific Gravity.**

	No. 9.	No. 10.
Specific gravity in block	2·647	2·631
Specific gravity in powder ...	2·653	2·652
Volume of voids	0·23%	0·80%

The percentage of water absorbed by the samples was determined and found to be— **Absorption of Water.**

	No. 9.	No. 10.
	Per cent.	Per cent.
Water absorbed	0·25	1·21

Freezing Tests.—(See page 18.) The test pieces were subjected to 10 alternations of frost and thaw— **Resistance to Weathering and Corrosion.**

	Wet.	Dry.
No. 9	Sample unaffected.	Sample unaffected.
No. 10	Do.	Do.

Corrosion Tests.—(See page 18.) The test pieces were exposed to the action of sulphurous acid for 5 days—

	Wet.	Dry.
No. 9	Sample unaffected.	Sample unaffected.
No. 10	Do.	Do.

A more severe test was made by subjecting the specimens to the action of hydrochloric acid (10 per cent. H Cl) for 14 days.

No. 9 ...Ferruginous constituents slightly attacked: colour considerably lighter.
No. 10... Do. do. do. do. do. do. do.

Structure.

Sample No. 9 consists of quartz, biotite, orthoclase, microcline and plagioclase. Chlorite and epidote are also present, the latter being abundant. The felspars are considerably altered and broken and contain numerous inclusions.

In sample No. 10 the quartz is in small crystals ; the felspars are much broken up and seriously decomposed. The mica (biotite) is also greatly altered. The stone is in a state of decay.

A single sample marked No. 11, Pallavaram, referred to in a letter, dated July 21st, from Messrs. Barry to yourselves was similarly examined.

PALLAVARAM.

Labelled—"No. 11, P. G. Messent, Esq., M.I.C.E., Engineer on Special Duty, Bombay Port Trust, Bombay, from Manager, Indian Granite Co."

Chemical Composition.

	Per cent.
Silica (SiO_2)...	57·82
Titanic Acid (TiO_2)	0·70
Alumina (Al_2O_3)	20·84
Ferric Oxide (Fe_2O_3)	3·58
Ferrous Oxide (FeO)	3·71
Lime (CaO)	5·16
Magnesia (MgO)	3·02
Potash (K_2O)	0·97
Soda (Na_2O)	3·64
Combined water and loss	0·56
	100·00

Resistance to Thrusting Stress.—The results of the compressive test made by yourselves are as follows :— **Mechanical Tests.**

Test No.	Base Area.	Crushed. Tons per square foot.
M.M. 2243	15·48 Sq. in.	1,410

Resistance to Abrasion.—The percentage of loss ascertained in the manner described above (page 18) was—

4·38 per cent.

The specific gravity of the stone in its natural state and after it had been powdered was determined— **Specific Gravity.**

Specific gravity in block	...	2·865
Specific gravity in powder	...	2·866
Volume of voids	...	*Nil.*

The percentage of water absorbed by the sample was determined and found to be **0·12** per cent. **Absorption of Water.**

Freezing Tests.—(See page 18.) The test pieces were subjected to 10 alternations of frost and thaw— **Resistance to Weathering and Corrosion.**

Wet.	Dry.
Sample unaffected.	Sample unaffected.

Corrosion Tests.—(See page 18). The test pieces were exposed to the action of sulphurous acid for 5 days—

Wet, 5 days.	Dry, 5 days.
Sample unaffected.	Sample unaffected.

A more severe test was made by subjecting the specimen to the action of hydrochloric acid (10 per cent. H Cl) for 14 days.

Ferruginous constituents slightly attacked: Colour somewhat lighter: garnets became more noticeable.

Structure. The sample is not a granite, but may be described as a garnetiferous, quartz-mica-diorite. It contains a considerable quantity of enstatite (a silicate of magnesia) as well as quartz, felspar and biotite. A large number of garnets are present. Magnetite and pyrites are scattered throughout the mass.

Another single specimen marked Harihar A (No. 12) was subjected to the same series of tests :—

Chemical Composition.

HARIHAR No. 12.

	Per cent.
Silica (SiO_2)	71·80
Titanic Acid (TiO_2)...	Trace.
Alumina (Al_2O_3)	17·14
Ferric Oxide (Fe_2O_3)	1·20
Ferrous Oxide (FeO)	0·54
Lime (CaO)...	1·40
Magnesia (MgO)	0·39
Potash (K_2O)	4·04
Soda (Na_2O)	3·43
Combined water and loss	0·17
	100·00

Mechanical Tests. **Resistance to Thrusting Stress.**—The results of the compressive test made by yourselves are as follows :—

Test No.	Base Area.	Crushed. Tons per sq. foot.
M. M. 3144	16·00 Sq. in.	1,504.

Resistance to Abrasion.—The percentage of loss ascertained in the manner described above (page 18) was

5·56 per cent.

The specific gravity of the stone in its natural state and after it had been powdered was determined— **Specific Gravity.**

Specific gravity in block ...	...	2·625
Specific gravity in powder...	...	2·637
Volume of voids	...	0·46 per cent. of volume of stone.

The percentage of water absorbed by the sample was determined and found to be **Absorption of Water.**

0·23 per cent.

Freezing Tests.—(See page 18.) The test pieces were subjected to 10 alternations of frost and thaw— **Resistance to Weathering and Corrosion.**

Wet.	Dry.
Sample unaffected ...	Sample unaffected.

Corrosion Tests.—(See page 18.) The test pieces were exposed to the action of sulphurous acid for 5 days—

Wet, 5 days.	Dry, 5 days.
Sample unaffected ...	Sample unaffected.

A more severe test was made by subjecting the specimen to the action of hydrochloric acid (10 per cent. H Cl) for 14 days.

Ferruginous constituents slightly attacked : colour somewhat lighter.

The sample is composed of quartz, felspar (both orthoclase and plagioclase) and mica (biotite). The felspar is considerably cracked and the biotite in places is altered to chlorite. This mechanical and chemical decay account for the relatively low compressive strength and high loss by abrasion. **Structure.**

Conclusions.

From a consideration of the data recorded above I have arrived at the following opinion.

The Indian samples with one or two exceptions are equal to or better than the standard samples in respect of their compressive strength, resistance to abrasion, absorption of water, and freedom from voids. In structure there are two characteristic differences. In the first place none of the Indian samples contains muscovite or white mica ; in every case the mica is of the dark variety (biotite) ; in the Aberdeen and Cornish samples muscovite is present, but is absent from the Norwegian specimen. I do not regard the fact that in the Indian granites the mica is solely biotite as any mark of mechanical inferiority. Secondly the dominant species of felspar in the standard samples is potash felspar, whereas soda felspar is more abundant in the Indian samples. As mentioned on page 22 the opinion is generally held that potash felspars are more resistant to weathering than soda felspars, and, accepting this view, the Indian granites are in this respect less excellent than the standard samples. But having regard to the fact that a series of corrosion tests of a somewhat severe kind have been successfully resisted by the Indian specimens, I consider that the deviation from the composition usually approved is not of serious significance.

In choosing between the various specimens of Indian granite, it is necessary to take into account not merely the properties of the specimens in their present state, but to forecast, as far as is possible, their future condition when they have been put to use. Thus a stone may have good mechanical strength and resist abrasion well, but if its structure is such as to favour attack, it may fail to weather well in practice. Such considerations have been regarded in arriving at a judgment of the relative quality of the present samples.

Two of the specimens may be eliminated at once. No. 10 is weak, decayed and friable. No. 11 is not a granite and is mechanically inferior to the other samples. No. 12 is of only moderate mechanical strength and its microstructure is poor. No. 9, though of good strength, has suffered considerable alteration and is of only moderate quality. The broken up condition of the quartz of No. 8 and its somewhat large loss by abrasion cause it to rank as mediocre. Nos. 6 and 7 are of fair quality, but their gneissose structure and the cracked condition of their quartz and felspar are against their selection.

The two remaining groups are Nos. 4 and 5 from Munirabad, and Nos. 1, 2 and 3 from Raichur. No. 4 on account of its cracked structure has a rather low compressive strength and high loss by abrasion ; it may be put aside. No. 5 is

a good stone but falls just short of first grade, because of the fact that its felspar and mica show definite signs of alteration. No. 1, Raichur, also shows some alteration and its loss by abrasion is appreciable. No. 2, Raichur, is similar to No. 1, but slightly better in this latter respect. No. 3, Raichur, is the best of all the samples. It has a normal chemical composition, a high compressive strength, good resistance to abrasion, low absorption and negligible volume of voids, and its microstructure is satisfactory.

For convenience of reference I have ranked all the specimens as follows :—

No. and Name of Sample.	Order of Merit.	
No. 3, Raichur...	1	(Best sample.)
No. 2, Raichur	2	
No. 1, Raichur No. 5, Munirabad } ...	3	
No. 6, Khanapur No. 7, Khanapur } ...	4	
No. 9, Karwar	5	
No. 4, Munirabad No. 8, Nagargali } ...	6	
No. 12, Harihar A	7	
No. 10, Karwar B	8	
No. 11, Not being a granite is not ranked.		

Yours faithfully,
BERTRAM BLOUNT.

Composition of the Minerals mentioned in the Microscopical Section.

Phosphate of lime, fluoride and chloride often present. **Apatite** (accessory).

Dark mica, magnesia mica. **Biotite** (essential).
Silicate of magnesia, potash, iron and alumina.
Composition very variable. (In most of the samples).

Hydrous silicate of magnesia, alumina and iron (ferrous). **Chlorite** (accessory).
Often derived from biotite as an alteration product. (See Nos. 8 & 9).

Muscovite (essential and accessory). White mica, potash mica.

Silicate of alumina, potash and iron (ferrous) magnesia, soda, lime, hydrofluoric acid and water often present in small quantities. More resistant to decomposition than biotite (See British Granites).

Enstatite (accessory). Silicate of magnesia, usually contains iron (Ferrous). (See No. 11).

Epidote (accessory). Silicate of alumina, lime and iron (Ferrous) with some manganese and water. Often derived from felspars, etc., as a decomposition product. (See No. 9).

Garnet (accessory). Belongs to large section. Composition very variable, chiefly silicate of alumina and lime with iron, magnesia and manganese. (See No. 11).

Microcline. (essential and accessory). A triclinic felspar, silicate of alumina and potash; usually contains soda also. (See Nos. 1, 4 and 6 and Norwegian).

Orthoclase (essential). Monoclinic felspar, potash felspar.

Silicate of alumina and potash, often contains soda, magnesia and lime (in most of the samples).

Plagioclase felspars (essential and accessory). Triclinic felspar, soda felspar.

Albite, oligoclase, labradorite and anorthite are the chief plagioclase felspars; they have not been differentiated in this report.

Silicates of alumina, soda and lime with potash, iron and magnesia (in most of the Indian samples).

Magnetite (accessory). Ferrous and ferric oxides. (In many of the samples).

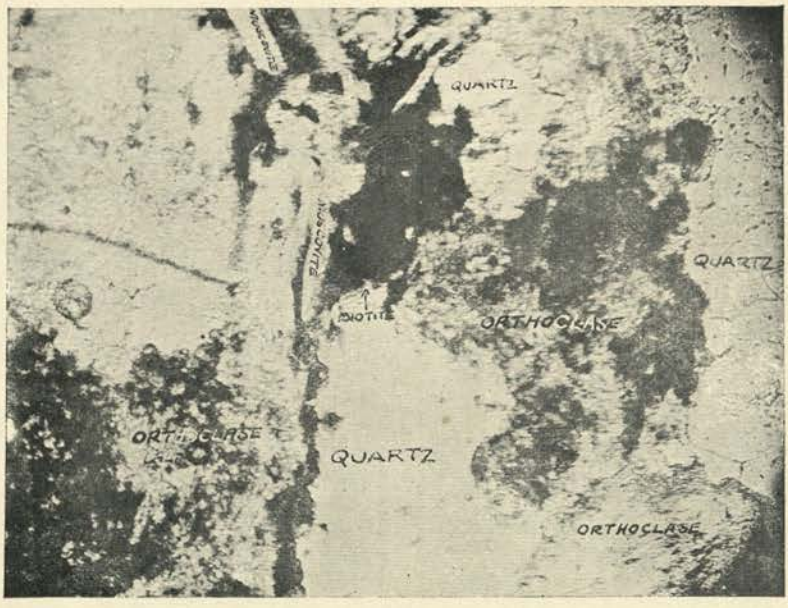
Pyrites (accessory). Bisulphide of iron. (See No. 10.)

Quartz (essential). Silica (In all the samples).

Sphene (accessory). Silicate of titanium and lime.

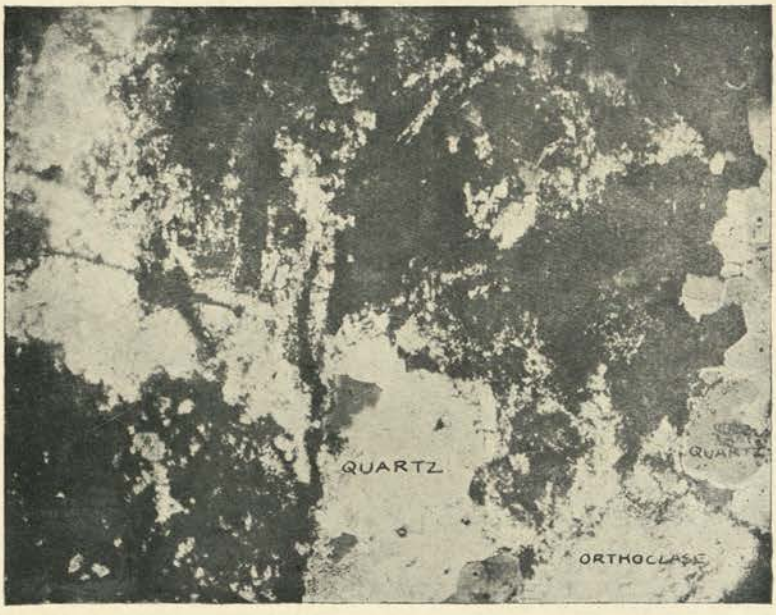
ABERDEEN.

ORDINARY TRANSMITTED LIGHT. × 60.



Dark patch of biotite near top of slide and a layer runs to the bottom associated with muscovite. The central white patch is granular quartz with altered orthoclase on either side. Crystal of fresh orthoclase at bottom on right.

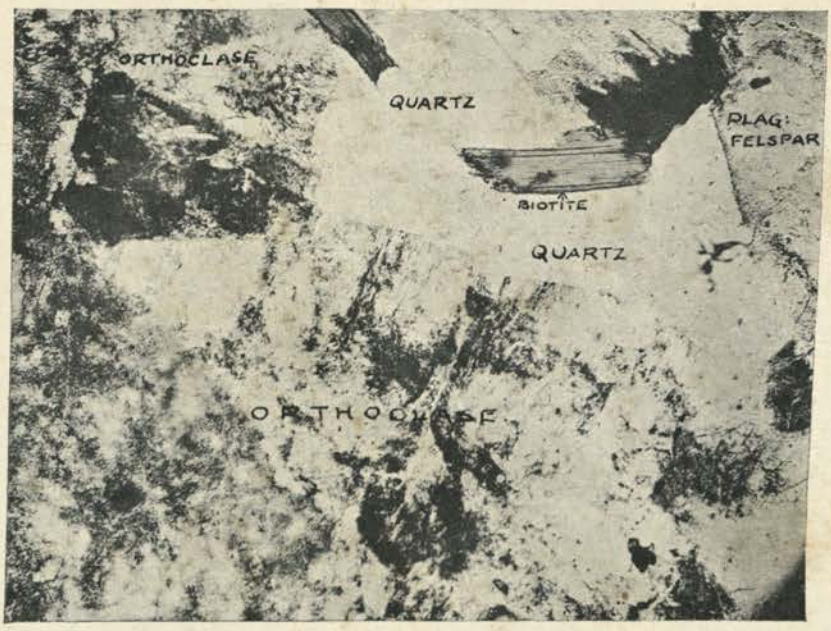
POLARIZED LIGHT. × 60.



Similar differentiation.

CORNISH.

ORDINARY TRANSMITTED LIGHT. × 60.



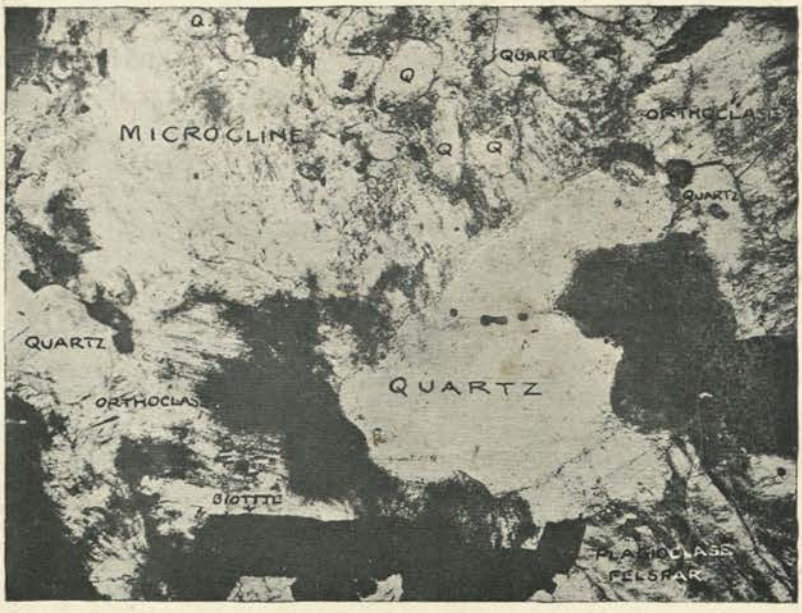
Two pieces of fibrous biotite at top ; black mass also biotite. The greater portion of field is orthoclase with dusky alteration products ; clear patch-quartz. Cystal of plagioclase at top right.

POLARIZED LIGHT × 60

Shows up quartz and twinned orthoclase running diagonally.

NORWEGIAN.

ORDINARY TRANSMITTED LIGHT. × 60.



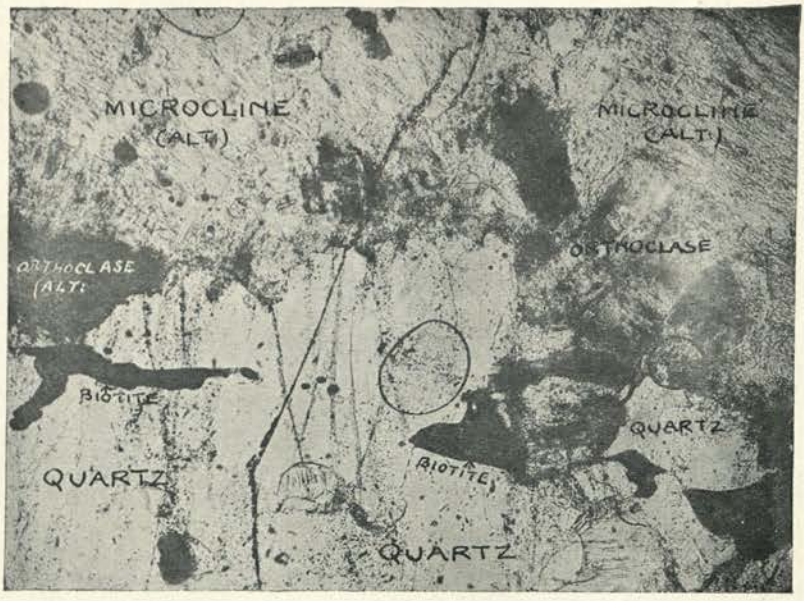
Large crystal of quartz on right; black patches adjoining altered orthoclase and biotite. Long black patch at bottom-biotite; magnetite in contact. Plagioclase on extreme right at bottom. Upper part microcline with included quartz granules.

POLARIZED LIGHT × 60.

Cross hatching of microcline very distinct; large quartz crystal seen to consist of two parts.

No. 1, RAICHUR, Quarry 1 mile from Station (E).

ORDINARY TRANSMITTED LIGHT. × 60.



Bottom half of field consists of quartz, crack running down, thin black patch of biotite on extreme left, altered orthoclase above it.

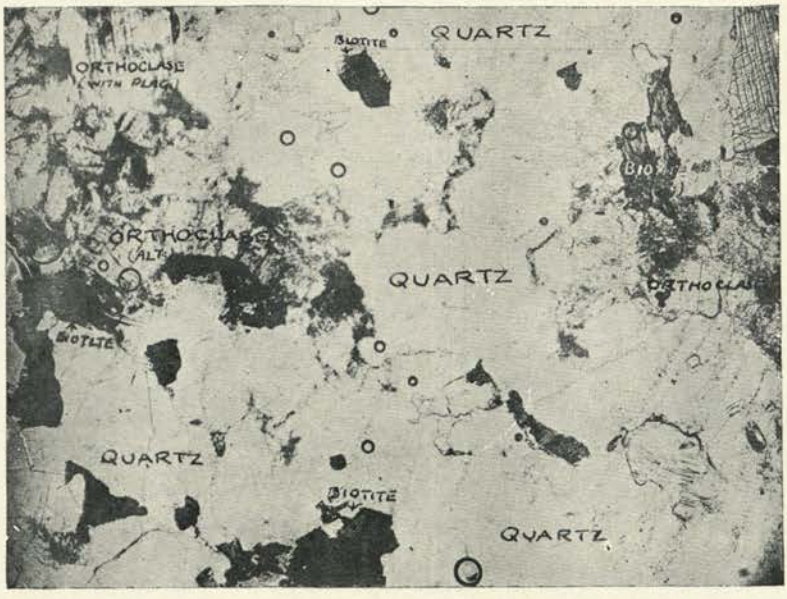
Top half consists of microcline with inclusions of orthoclase; between the microcline and quartz, crystals of orthoclase more or less altered. Wedge-shaped black patch biotite.

POLARIZED LIGHT × 60.

Quartz seen to be divided, cross hatching of microcline apparent.

No. 2, RAICHUR, Quarry 1 mile from Station (E).

ORDINARY TRANSMITTED LIGHT. × 30.



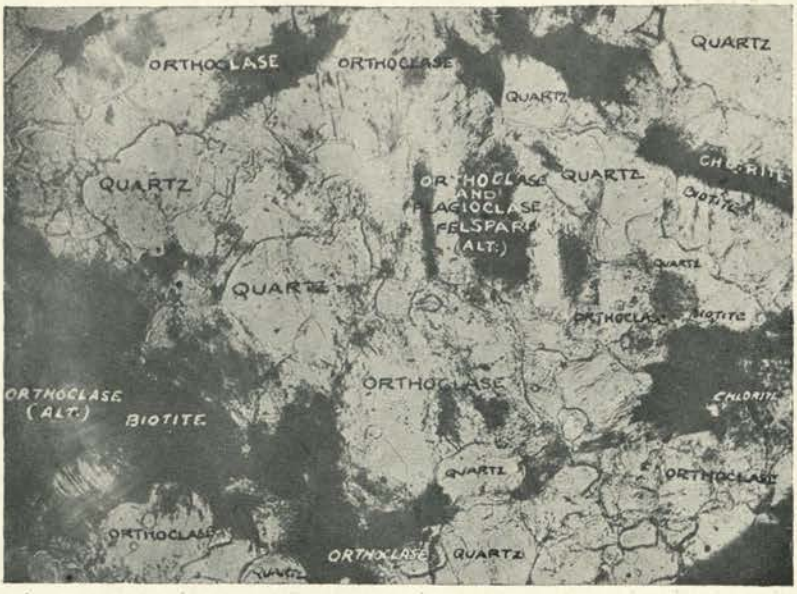
Consists chiefly of quartz, much broken up in places, orthoclase in isolated crystals, little altered. Biotite scattered throughout the field.

POLARIZED LIGHT × 30.

Shows broken up appearance of quartz.

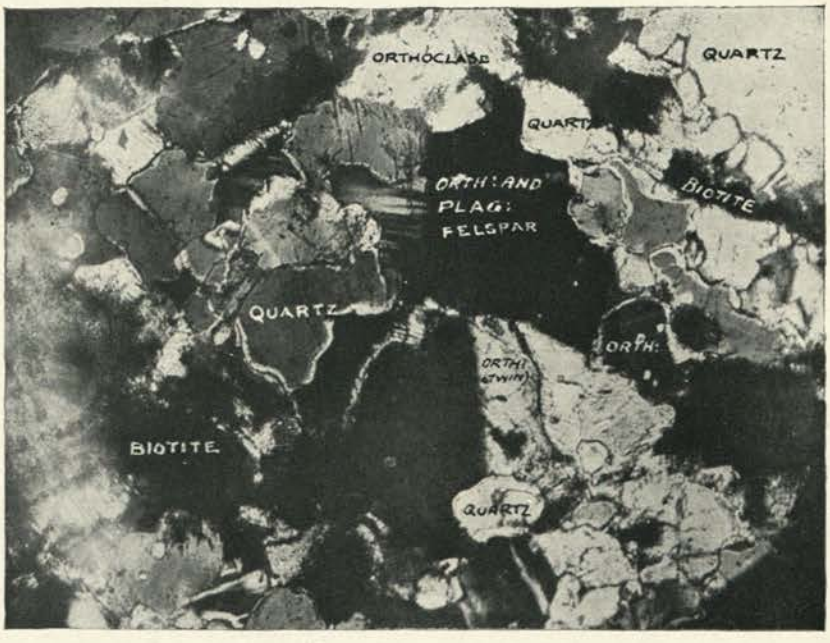
No. 3, RAICHUR, Quarry 3 miles from Station (N.-E).

ORDINARY TRANSMITTED LIGHT. × 60.



Orthoclase, quartz and plagioclase distributed throughout the field. Biotite and chlorite in patches and streaks.

POLARIZED LIGHT. × 60.



Plagioclase felspar, black patch just above centre. Orthoclase twin below.

No. 4, MUNIRABAD.

ORDINARY TRANSMITTED LIGHT. × 30.

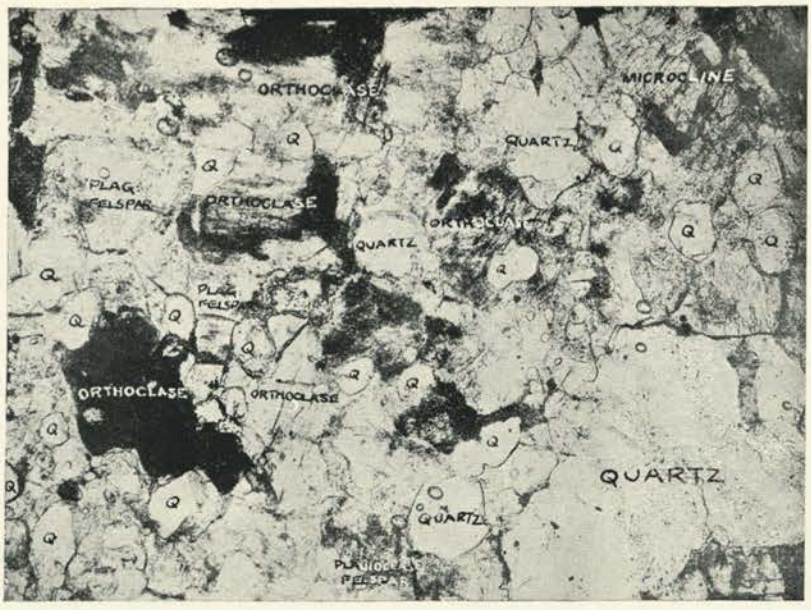
Large area of quartz running across field, a patch of much altered biotite towards the left. Large crystals of orthoclase and plagioclase much corroded microcline below.

POLARIZED LIGHT. × 30.

The quartz is shown to consist of large and small crystals; cross-hatching of microcline noticeable.

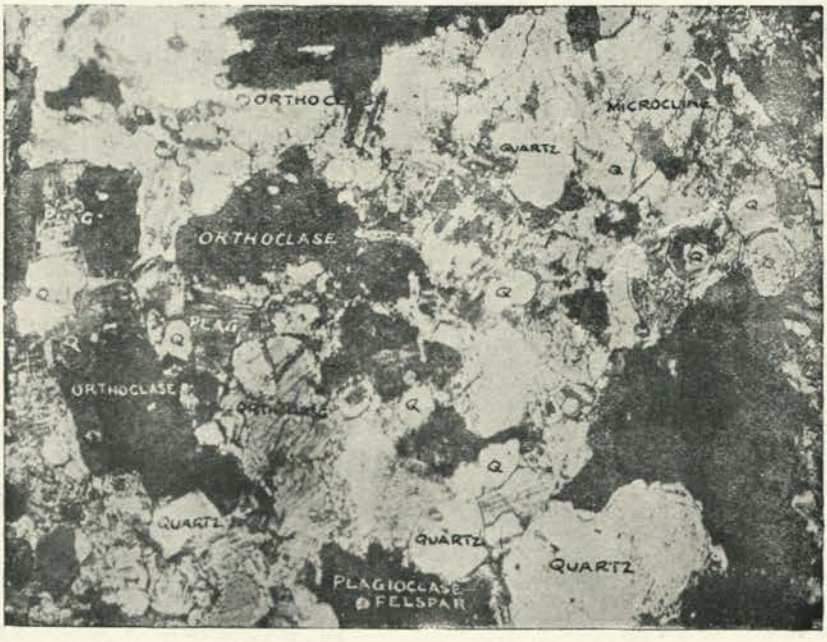
No. 5, MUNIRABAD.

ORDINARY TRANSMITTED LIGHT. × 30.



Orthoclase, microcline, quartz and plagioclase scattered throughout the field ; the quartz is seen in granules associated with the felspars.

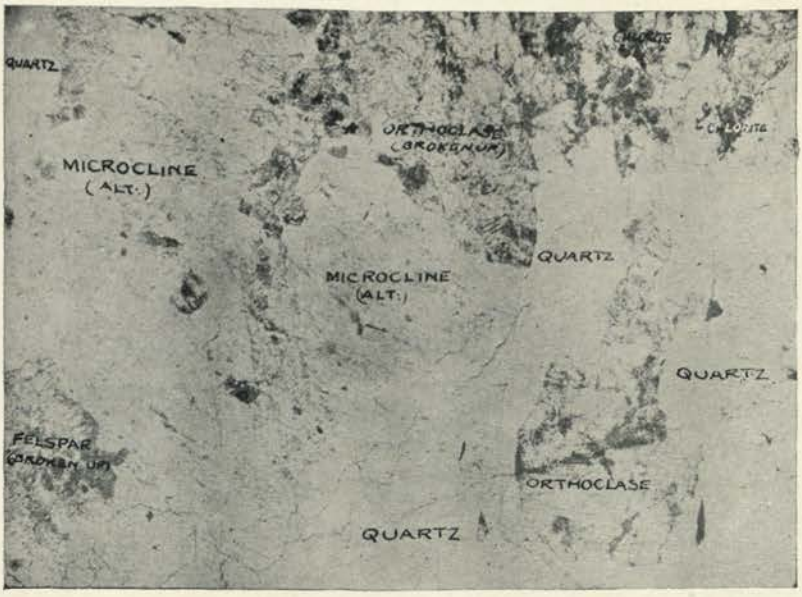
POLARIZED LIGHT. × 30.



Shows striated appearance of plagioclase and microline in places ; large crystal of quartz at bottom seen to consist of two pieces.

No. 6, KHANAPUR.

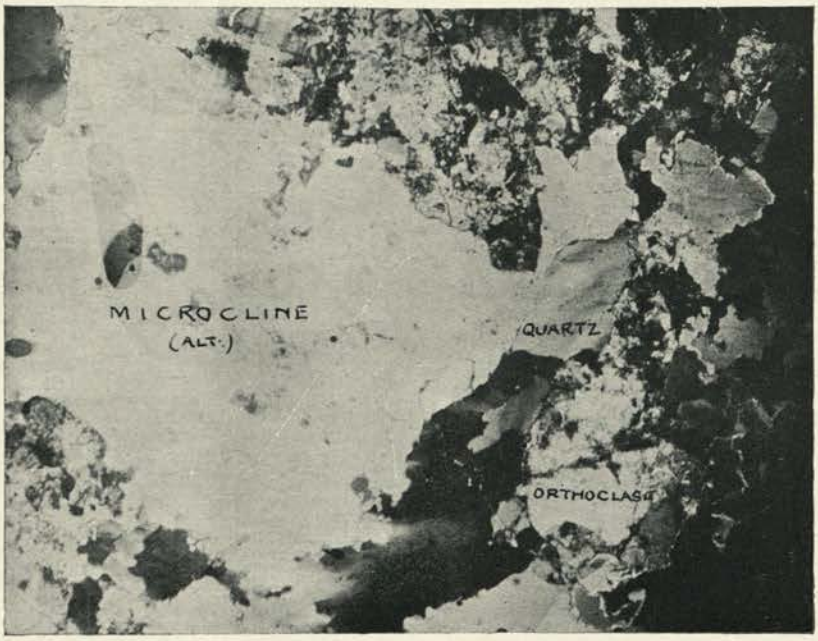
ORDINARY TRANSMITTED LIGHT. × 30.



Vein of quartz seen running up the field, showing gneissose structure, orthoclase between the veins

Microcline and broken up orthoclase constitute remainder of slide.

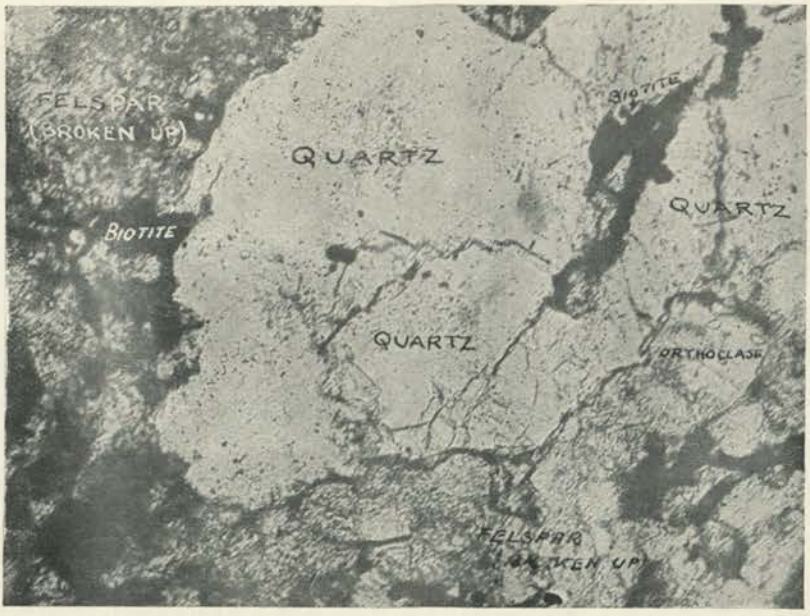
POLARIZED LIGHT. × 30.



Quartz seen to be split up; gneissose structure emphasized.

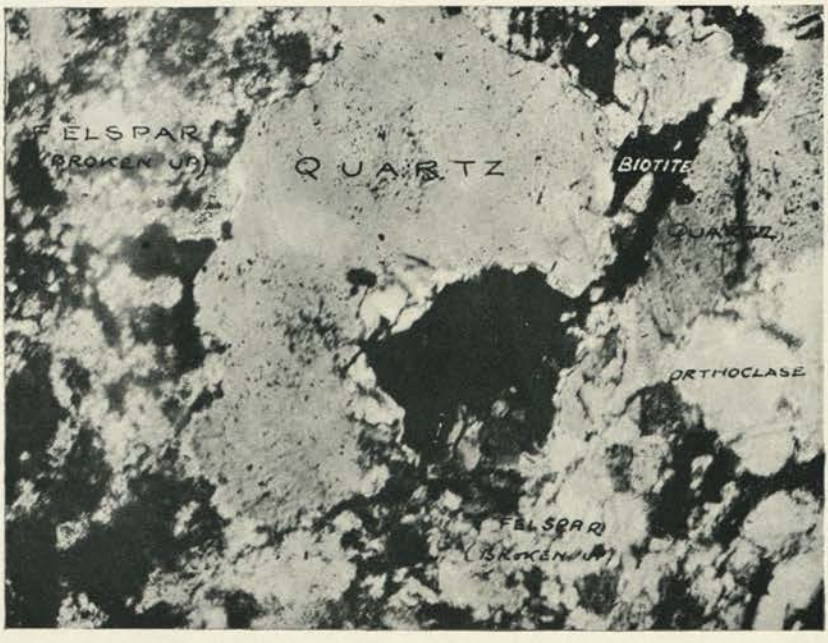
No. 7, KHANAPUR.

ORDINARY TRANSMITTED LIGHT. × 60.



Large central area of quartz, the rest is chiefly broken up and decomposed orthoclase ; biotite in ragged streaks.

POLARIZED LIGHT. × 60.

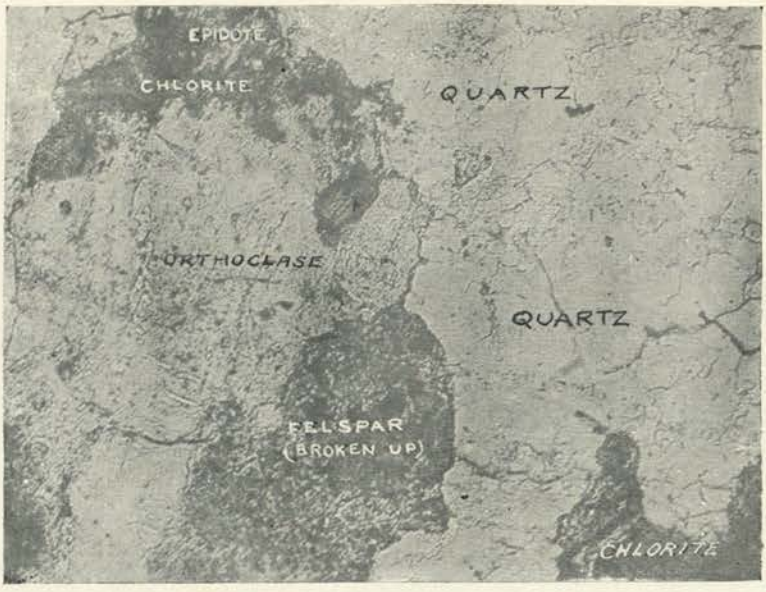


Central crystal of quartz black.

(The photographs do not fully indicate the gneissose structure which is characteristic of other parts of the section.)

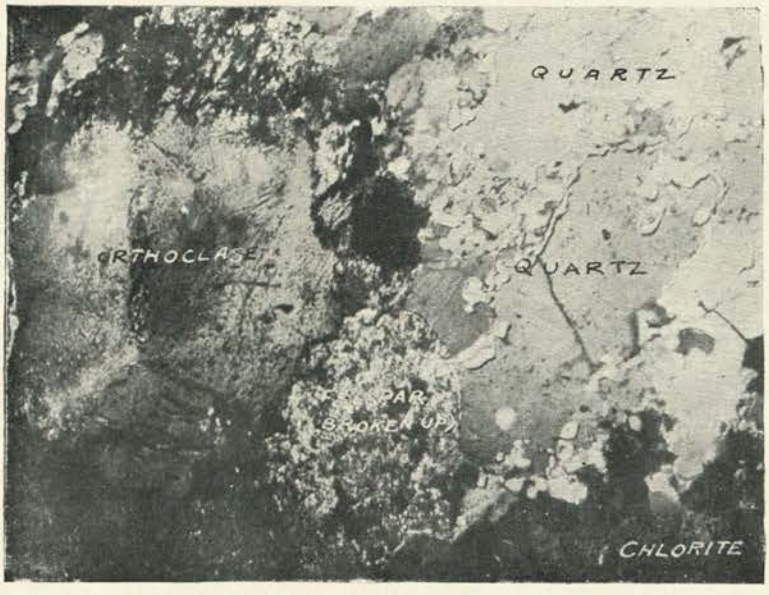
No. 8, NAGARGALI.

ORDINARY TRANSMITTED LIGHT. × 60.



The whole of the right side, quartz, much broken up ; on the left felspar both fresh and altered, some decomposed and corroded ; cloudy patch on top epidote (alteration product) and chlorite.

POLARIZED LIGHT. × 60.



Accentuates broken up condition of quartz.

63740

No. 9, KARWAR.

ORDINARY TRANSMITTED LIGHT. × 60.

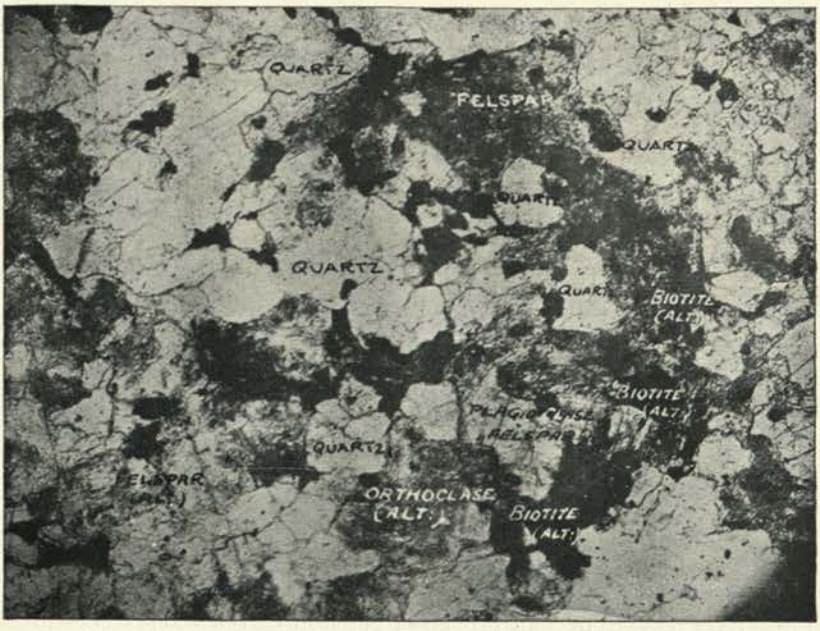
Large central area of quartz surrounded by corroded felspar containing numerous inclusions ; dark patches of chlorite ; epidote as an alteration product ; patch of biotite in right-hand lower corner.

POLARIZED LIGHT. × 60

Shews broken up condition of quartz ; lamellar twinning of plagioclase noticeable.

No. 10, KARWAR.

ORDINARY TRANSMITTED LIGHT × 30.



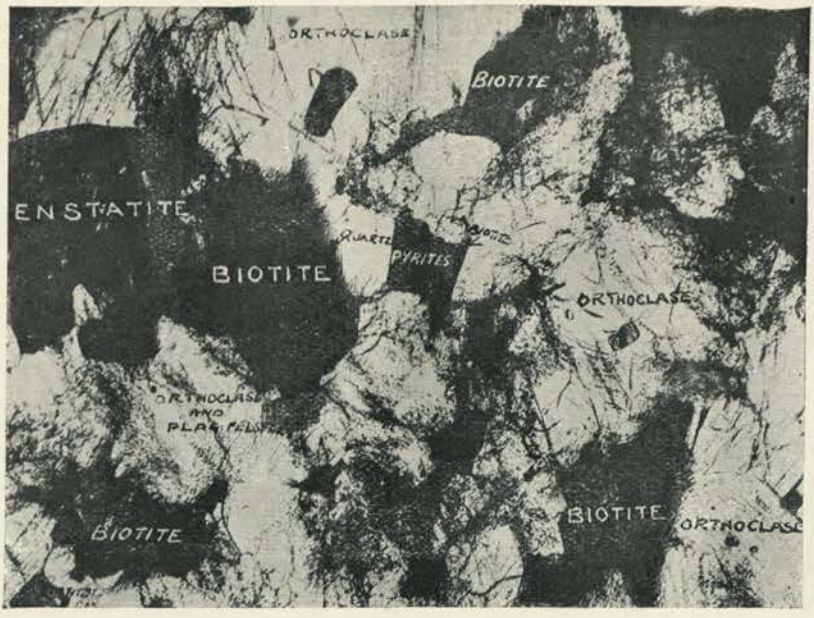
Granular quartz and altered felspars in interlocked granules. Biotite (altered) scattered throughout the field-staining adjacent crystals.

POLARIZED LIGHT. × 30.

Lamellar twinning of plagioclase noticeable.

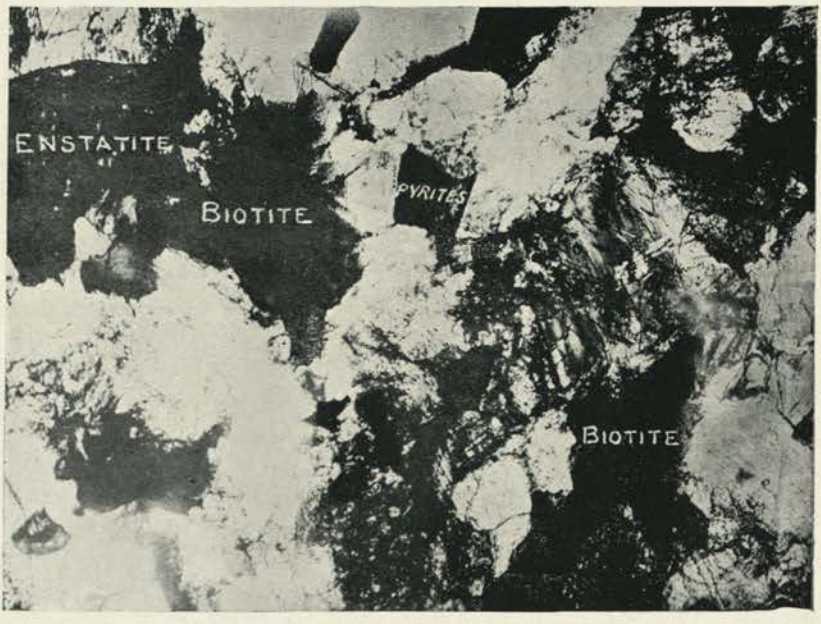
No. 11, PALLAVERAM.

ORDINARY TRANSMITTED LIGHT. × 60.



Large dark patches of biotite; black patch at extreme top left enstatite. The rest of slide chiefly orthoclase; very little quartz. Rectangular black patch above centre pyrites with biotite.

POLARIZED LIGHT. × 60.



Structure similarly differentiated.

[This portion of the section happens to contain no garnets; they are however abundant in the rock.]

No. 12, HARIHAR A.

ORDINARY TRANSMITTED LIGHT. × 60.

Quartz running across field from bottom left to top right; plagioclase in top left corner also at bottom right. Two dark patches of biotite (much altered).

POLARIZED LIGHT. × 60.

Dark shaded crystal of plagioclase seen between crystals of quartz.

BOMBAY PORT TRUST.

No. 374—12.

7, THE SANCTUARY, WESTMINSTER, S.W.,
October 14th, 1904.

THE CHIEF ENGINEER,
BOMBAY PORT TRUST.
New Docks.

SIR,

With reference to your letters, Nos. $\frac{2204}{75}$ and $\frac{2654}{75}$, dated the 9th July and 20th August, respectively, forwarding for examination six samples of Godhra granite, we have the honour to forward herewith, in original, Messrs. Kirkaldy and Son's report, dated 11th October, in tabular form, on these samples. Portions of these samples are now being dealt with by Mr. Blount, the Chemist, for the additional tests and analysis which he conducts; his report will follow.

We have the honour to be,
Sir,
Your obedient Servants,
(Sd.) J. WOLFE BARRY & A. J. BARRY.

7, THE SANCTUARY, WESTMINSTER, S.W.,
28th October 1904.

No. 6—13.

1 Enclosure.

THE CHIEF ENGINEER,
BOMBAY PORT TRUST,
BALLARD ROAD, BOMBAY.

SIR,

Granite for New Docks.

We have the honour to acknowledge receipt of your letter No. 3189-75, dated 8th instant, and now have pleasure in sending you Mr. Bertram Blount's report on the sample of "Godhra" Granite. You now have, we believe, reports on all the samples of Granite sent to us, and we should be glad to know, in due course, your decision as to whether you propose to use Indian or other Granite in connection with the New Docks at Bombay.

We have the honour to be,
Sir,
Your obedient servants,
(Sd.) SIR J. WOLFE BARRY & A. J. BARRY.

BOMBAY PORT TRUST.

New Docks, Mody Bay, Bombay.

Results of Experiments to ascertain the resistance to Thrusting Stress and the Porosity of samples of Granite, received from yourselves.

Thrusting Stress.										Porosity.					
Test No.	Name of Quarry and Marked.	Dimensions.	Base Area.	Crushed slightly.			Crushed.			Test No.	Description.	Before Immersion.	After 24 hours Immersion.	Difference.	Absorption.
				Stress.	Per Sq. Inch.	Per Sq. Foot.	Stress.	Per Sq. Inch.	Per Sq. Foot.						
M M	Received 4" cubes, dressed square.	inches.	sq. ins.	lbs.	lbs.	tons.	lbs.	lbs.	tons	M M	Irregular shapes.	lbs.	lbs.	lbs.	Per cent.
3989	"Godhra" A 13	3·46, 3·50×3·49	12·21	217,000	17,772	1,142·9	305,000	24,979	1,606·4	3992	"Godhra" A 13.	3·947	3·954	·007	0·18
3990	„ B 14	3·46, 3·50×3·50	12·25	246,000	20,082	1,291·4	316,300	25,820	1,660·4	3993	„ B 14 ...	3·721	3·724	·003	0·08
3991	„ C 15	3·44, 3·50×3·49	12·21	312,600	25,602	1,646·4	345,700	28,313	1,820·8	3994	„ C 15 ...	2·442	2·447	·005	0·20
		Mean ...	12·22	258,533	21,152	1,360·2	322,333	26,371	1,695·9					Mean	0·15

Cubes were ground true.

99, Southwark Street,
London, S.E., 11*th October* 1904.

DAVID KIRKALDY & SON.

To Sir J. WOLFE BARRY and A. J. BARRY, Esq., C.E.,
7, The Sanctuary, Westminster, S. W.

76 & 78, York Street, Westminster,
London, S. W., *October* 18*th*, 1904.

No. 476 of 1904.

Investigation *re* Granite.

To

Messrs. David Kirkaldy & Son,
99, Southwark Street, S. E.

Dear Sirs,

In accordance with your instructions I have examined fully a sample of Indian granite received from you on September 22nd. The sample consisted of 3 pieces marked "Godhra 13-A, 14-B, 15-C," but as they evidently represented the same stone I have dealt with 1 only, *viz.*, "14-B."

Chemical Composition.

GODHRA 14-B.

	Per cent.
Silica (SiO_2)	71·78
Titanic Acid (TiO_2)	Trace.
Alumina (Al_2O_3)	14·12
Ferric Oxide (Fe_2O_3)	1·17
Ferrous Oxide (FeO)	1·27
Lime (CaO)	0·74
Magnesia (MgO)	0·42
Potash (K_2O)	6·04
Soda (Na_2O)	3·84
Combined water and loss	0·62
	100·00

Mechanical Tests.

Resistance to Thrusting Stress.—The results of the compressive test made by yourselves are as follows:—

Test No.	Base Area.	Crushed. Tons per sq. foot.
M. M. 3990 ...	12·25 Sq. in. ...	1,660
Crushed slightly at 1,291 tons per sq. foot.		

Resistance to Abrasion.—The method adopted for this test was as follows. A cube was cut of approximately 1 inch side and was rumbled in a

mill with flint pebbles until the angles had been rounded. It was then weighed and again rumbled for two hours. The loss of weight was ascertained and is stated in terms of the weight of the sample after the first treatment. The object of the preliminary rumbling was to remove sharp angles which might be chipped and cause a larger loss of weight than that properly due to the wear of the stone.

The percentage of loss ascertained in this way was

2·26 per cent.

Specific Gravity. The specific gravity of the stone in its natural state and after it had been powdered was determined—

Specific gravity in block ...	...	2·642
Specific gravity in powder...	...	2·685

Volume of voids 1·16 per cent. of volume of stone.

Absorption of Water. The percentage of water absorbed by the sample was determined and found to be

0·14 per cent.

Resistance to Weathering and Corrosion. **Freezing Tests.**—Test pieces having both rough and polished surfaces were exposed to a temperature below freezing and were then thawed. The operation was repeated so that in all ten alternations were made—

Wet.	Dry.
Sample unaffected.	Sample unaffected.

Corrosion Tests.—Similar test pieces were exposed to the action of sulphurous acid for 5 days in order to simulate the influence of the air of large towns using coal as a fuel. As in the previous case wet and dry tests were made.

Wet, 5 days.	Dry, 5 days.
Sample unaffected.	Sample unaffected.

A more severe test was made by subjecting a specimen to the action of hydrochloric acid (10 per cent. H Cl) for 14 days.

Ferruginous constituents slightly attacked: Colour became somewhat lighter.

Structure. The granite consists of quartz and felspar in about equal proportions together with a moderate quantity of mica (biotite). The crystals of quartz are somewhat large, and in places the quartz occurs as granules included in the felspar. The felspar is chiefly orthoclase and is considerably altered. Apatite and rutile occur as accessory constituents.

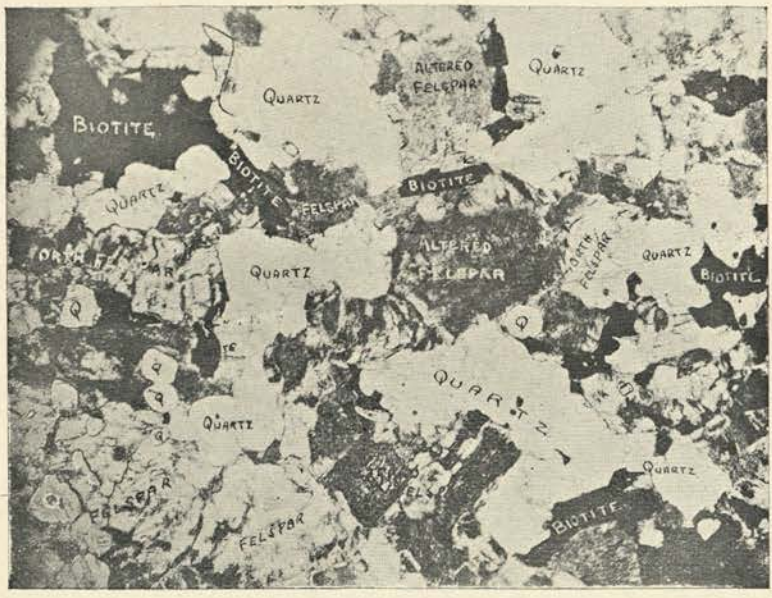
Conclusion.

The granite has only a moderate crushing strength ; it resists abrasion fairly. As shown by the proportion of voids and by direct miscroscopical examination, its structure is not so close as desirable. The stone must be regarded as of mediocre quality.

Yours faithfully,
BERTRAM BLOUNT.

GODHRA, 14-B.

ORDINARY TRANSMITTED LIGHT. × 30.



Quartz occurs uniformly over the field in large crystals, blebs included in felspar. Altered orthoclase runs from top to bottom down centre. In bottom left hand corner orthoclase felspar not much altered with inclusions of quartz. Patches of biotite in top left and bottom right hand corners.

POLARIZED LIGHT. × 30.

The three large patches of quartz (2 top 1 bottom) are seen to consist of several crystals. The much altered felspar is contrasted with the comparatively fresh felspar.

APPENDICES.

No. 3390-Mis.

BOARD OF REVENUE,

REV. SETLT., LAND RECORDS AND AGRI.,

MADRAS, *4th July* 1904.

From

M.R.RY. V. K. RAMANUJACHARIAR AVARGAL, B.A.,

SECRETARY TO THE COMMISSIONER OF REVENUE SETTLEMENT,

AND DIRECTOR, DEPARTMENT OF LAND RECORDS AND AGRICULTURE,

Madras,

To

THE SECRETARY,

BOMBAY PORT TRUST,

Bombay.

SIR,

With reference to your letter No. 186, dated 14th January 1904, to the Secretary to Government, Public Works Department, I am directed to forward a statement in tabular form embodying the information furnished by District Officers regarding granite and granite quarries in the several districts of the Madras Presidency. The statement does not show the cost of carriage by rail or by sea, which should be ascertained separately.

I have, &c.,

V. K. RAMANUJACHARIAR,

Secretary.

STATEMENT showing the situation of Granite Quarries, the Quality and Cost

District and Taluk.	Village in which Quarry is Situated.	Nearest Railway Station.		Quality of Stone.
		Name.	Its distance from the Quarry.	
1. Vizagapatam Dist.* ...	.....	.....	.....	.....
2. Godavari District—				
Chodavaram Division	Korakonda near Purushottapatnam.	Rajamundry ...	22 miles ...	Sufficiently hard for "stone in chunam" work.
3. Kistna District—				
(1) Sattanapale Taluk...	Sattanapale	Sattanapale Road* on the S. M. Ry.	Within a radius of 3 miles from the Railway Station.	Good quality. It is regularly quarried for irrigation works and Railway Bridges.
(2) Bezwada Taluk ...	Kondapalli	Kondapalli ...	.....	The stone has not been tried by any Department.
4. Bellary District—				
(1) Bellary Taluk ...	1. Bellary	Bellary*	Within one mile.	White and mixture of white and black colour burnt.
	2. Sankarahanda ...	Do.	4 miles ...	Burnt stone ...
	3. Mundrigi	Do.	Do. ...	Do. ...
	4. Sanganakallu ...	Do.	Do. ...	Do. ...
	5. Kudatini	Kudatini	3 miles ...	Do. ...
(2) Rayadrug Taluk ...	Rayadrug	Bellary	33 ,, ...	Do. ...
(3) Adoni Taluk ...	1. Kuppagal ...	Kuppagal	1 mile ...	Unburnt ...
	2. Aralahanda ...	Kosigi	8 miles ...	Do. ...
	3. Duddi and Yendapalli.	Do.	3 ,, ...	Do. ...

* Places marked thus shown on map on page 13.

of the Stone Quarried, &c., in the several districts of the Madras Presidency.

Cost.	Cost of Carriage to the Railway Station.	REMARKS.
.....	.....	*Granite cannot be obtained in any appreciable quantity in the district. Diorite and granite of an extremely hard description occur in the Anakapalli and Viravilli taluks, but the local stone masons are unable to work them.
.....	.....	
(*a*) Random rubble Rs. 14-7-0 per 100 cubic feet, minimum thickness 9." (*b*) Large stones for carbels, Rs. 60-0-0. (*c*) Arch Vonosoier, Rs. 50-0-0.	.....	The stone is very easily dressed and was found admirable for the construction of piers, head sluices, etc.
.....	.....	The station is on the Nizam's Guaranteed State Railway line.
Rs. 4 for quarrying 100 cubic feet and Rs. 18 for rough dressing.	Two annas per mile	These are big quarries, and stones of required dimensions can be had and carted to Bellary without difficulty.
Do. ...	Do. ...	
Do. ...	Do. ...	
Do. ...	Do. ...	
Do. ...	Do. ...	
Rs. 16-10-8 per 100 cubic feet.	Do. ...	Facilities for carriage are poor.
Rs. 25 for quarrying 100 cubic feet and Rs. 100 for chisel dressing.	Do. ...	There are bandy tracks for the conveyance of these stones from the quarries.
Do. ...	Do. ...	
Rs. 8-12-0 for quarrying 100 cubic feet and Rs. 100 for dressing.	Do. ...	

STATEMENT showing the situation of Granite Quarries, the Quality and Cost

District and Taluk.	Village in which Quarry is Situated.	Nearest Railway Station.		Quality of Stone.
		Name.	Its distance from the Quarry.	
(4) Alur Taluk ...	1. Alur	Molagavalli ...	10 miles ...	Bluish colour ...
	2. Yerur	Bantanahal ...	3 „ ...	Do. ...
(5) Hadagalli Taluk ...	1. Holalgundi	Hospet ...	32 miles ...	Superior ...
	2. Dasarahalli	Do. ...	34 „ ...	Do. ...
	3. Pinjara Haggadahal ...	Do. ...	15 „ ...	Inferior... ...
5. Anantapur District—				
(1) Dharmavaram Taluk	1. Mallakawa	Dharmavaram* ...	3 miles ...	Superior quality...
	2. Regatipalle	Do. ...	3 „ ...	Do. ...
	3. Nagasamudram ...	Nagasamudram ...	1 mile ...	Do. ...
	4. Chennekottapalle ...	Do. ...	3 miles ...	Do. ...
(2) Tadpatri Taluk ...	Thambacheruon ...	Tadpatri ...	9 „ ...	Good quality ...
6. Cuddapah—				
Kadiri Taluk‡	.....	.....	.....	.....
7. Nellore§	.....	.....	.....	.. ...

* Places marked thus shown on map on page 13.

of the Stone Quarried, &c., in the several districts of the Madras Presidency—contd.

Cost.	Cost of Carriage to the Railway Station.	REMARKS.
Rs. 16-10-8 per 100 cubic feet.	Two annas per mile.	Stones cannot be had here in large blocks.
Slabs 7 × 1½ ft. vary from 8 to 12 annas according to thickness.	Re.1 for 10 miles.	Facilities for transport are poor.
.....		
* Chisel dressed Rs. 20 per 100 cubic feet. * Hammer dressed Rs. 12 per 100 cubic feet.	.....	* Exclusive of conveyance charges.
† Rs. 3½ or 4 per cubic yard.	.....	† Inclusive of conveyance charges.
.....	.....	‡ A variety of gneiss known as granite is procurable in this taluk in several villages. The cost of a stone 4 cubits long, 2 cubits wide and 6 inches thick is Rs. 1-4-0, and the cost of carting to the Railway Station is 8 annas a piece. In Kadiri and Tanakal, which are on the railway line, no expenditure on account of cartage will be necessary.
.....	.....	§ There are large quantities of gneiss and granite in the district, some of which make handsome building stone, but the places are so far away from the railway that it is hardly likely that it would pay to carry stone hence to Bombay.

STATEMENT showing the situation of Granite Quarries, the Quality and Cost

District and Taluk.	Village in which Quarry is Situated.	Nearest Railway Station.		Quality of Stone.
		Name.	Its distance from the Quarry.	
8. Chingleput—				
(1) Saidapet Taluk.	1. Thirusulam (2 quarries.)	Pallavaram* ...	2 miles ...	Dark-blue granite
	2. Thawbiram (2 quarries.)	Do. ...	4 „ ...	Do. ...
	3. Pulikoradu (2 quarries.)	Do. ...	4 „ ...	Do. ...
	4. Selaiyur	Do. ...	5 „ ...	Do. ...
	5. Erumaiyur	Do. ...	6 „ ...	Do. ...
	6. Kunnathur ...	Do. ...	3 „ ...	Do. ...
	7. Sikkarayapuram ...	Do. ...	8 „ ...	Do. ...
(2) Chingleput Taluk...	1. Olalur	Chengalpat* ...	3 „ ...	Do. ...
	2. Kilkalani	Do. ...	18 „ ...	Do. ...
	3. Pattipalagam ...	Do. ...	12 „ ...	Do. ...
	4. Venkatapuram ...	Singaperunal Koil.	4 „ ...	Do. ...
	5. Appur (2 quarries)...	Do. ...	4 „ ...	Grey granite ...
	6. Magn'yam (2 quarries)	Vandalur	5 „ ...	Dark-blue ...
	7. Nakambakkam ...	Do. ...	5 „ ...	Do. ...
	8. Unamangeri ...	Do. ...	4 „ ...	Do. ...
	9. Kalvoy (2 quarries).	Guduvancheri ...	5 „ ...	Grey ... ...
	10. Tailavaram... ...	Do. ...	2 „ ...	Do. ... ...
(3) Madurantakan Taluk.	Malapalayram... ...	Madurantakan ...	8 „ ...	Dark-blue ...

* Places marked thus shown on map on page 13.

of the Stone Quarried, &c., in the several districts of the Madras Presidency—contd.

Cost.	Cost of Carriage to the Railway Station.	Remarks.
(1) Blocks of 1 to 7 c. ft. ...	4 annas per cart-load.	The granite is said to be hard and durable and is used in the manufacture of grinding stones, mortars, pestles, pillars for house building purposess, and the like. The granite at Thirusulam takes a good polish and is used largely for tombstones, and for the carving of idols.
Rs. a. p.		
Rough... ... 0 10 0	8 annas.	
Rough dressing 0 12 0	8 „	
Smooth „ ... 1 4 0		
(2) Blocks of 7 to 12 c. ft.		
Rs. a. p.		
Rough... ... 0 12 0	10 „	
Rough dressing 0 15 0	12 „	
Smooth „ ... 1 8 0	6 „	
(3) Blocks of 12 to 20 c. ft.		
Rs. a. p.		
Rough... ... 1 0 0	1 Rupee.	
Rough dressing. 1 4 0		
Smooth „ ... 2 0 0		
See Saidapet Taluk ...	6 annas.	
	Re. 1 and 11 annas.	
	Rs. 1-2-0.	
	8 annas.	
	8 „	
	10 „	
	10 „	
	8 „	
	10 „	
	4 „	
.....	Re. 1.	

STATEMENT showing the situation of Granite Quarries, the Quantity and Cost

District and Taluk.	Village in which Quarry is Situated.	Nearest Railway Station.		Quality of Stone.
		Name.	Its distance from the Quarry.	
9. South Arcot—				
(1) Tindivanam Taluk.	Perumukkal	Tindivanam ...	7½ miles ...	Hard ... ...
(2) Villupuram Taluk...	1. Siruvakkur	Mambalapattu ...	2 „ ...	.....
	2. Tiruvakkarai ...	Villupuram* ...	10 to 15 miles.	.....
	3. Sengikunathur ...			
	4. Lagalumpundi ...			
	5. Tandavasamudram...			
	6. Mathu Tirukkai ...			
	7. Athyar Tirukkai ...			
	8. Sirupalar			
	9. Muttattur			
(3) Tirukkoilur Taluk...	1. Arakandanallur ...	Tirukkoilur ...	1 mile ...	Light mottled grey.
	2. Karadi & T. Kuhanur	Do. ...	3 miles ...	Do. ...
	3. Pidagaur	Do. ...	19 to 22 miles.	Do. ...
	4 Adukkam	Mogaiyur	2 to 4 „	Do. ...
(4) Tiruvamamalai Taluk	1. Kosalai	Tiruvamamali ...	4½ miles ...	Inferior ...
	2. Adiannamalai ...	Do. ...	Do. ...	Do. ...
(5) Kallakurichi Taluk.	1. Kollantangal Pakkirikunnu.	Tirukkerlur ...	19 miles ...	Burnt (inferior).
	2. Sithankunnu ...	Do. ...	Do. ...	Do. ...
*10. North Arcot ...	.....	.....	.....	.....

* Places marked thus shown on map on page 13.

of the Stone Quarried, &c., in the several districts of the Madras Presidency—contd.

Cost.	Cost of Carriage to the Railway Station.	Remarks.
.....	.....	The cost depends on the nature of the stones required. Carts can be had in the adjoining villages.
.....	.....	
Rs. 3 to 4 for stones 5 × $\frac{3}{4}$ × $\frac{3}{4}$ cubic feet at the quarry.	Two annas per mile.	The cost of the stone depends on its dimensions. The places are accessible from the Railway Station by carts.
Rs. 5-8-0 per 100 cubic feet at the quarry.	.....	Country carts are available in all the villages, but the Pennar has to be crossed in the case of quarries Nos. 2 and 3.
6 annas per 1 cubic foot and 4 annas for chiselling roughly.	One anna per 1 cubic ft.	The stones are not sufficiently hard to be used for docks.
A slab of 11 × 2 × $\frac{1}{2}$ cubic feet costs Rs. 2.	Rs. 2-4-0 per cart-load.	The Pennar has to be crossed before reaching the Railway Station and the stones can be carted only for a few months in the year.
.....	.....	* Granite of excellent quality is obtainable near Sholinghar Railway Station. It works and dresses well and can be taken out in blocks of any size. The quarries are favourably situated for transport of material. The cost of large granite blocks delivered at the station would be 5 to 5½ annas per cubic foot according to the size of the blocks required. This rate includes seigniorage fees also.

STATEMENT showing the situation of Granite Quarries, the Quality and Cost

District and Taluk.	Village in which Quarry is Situated.	Nearest Railway Station.		Quality of Stone.
		Name.	Its distance from the Quary.	
11. Salem District—				
(1) Hosur Taluk ...	1. Chudavadi	Malur	20½ miles ...	Durable ...
	2. Erratinaganapalli ...	Do.	22 „ ...	
	3. Onnalavadi... ...	Do.	25 „ ...	
	4. Kasnanthoddi ..	Do.	29 „ ...	
	5. Nallur	Do.	16 „ ...	
	6. Kommuchimapalle ...	Do.	39 „ ...	
	7. Erratiagraharam ...	Do.	36 „ ...	
(2) Dharmapuri Taluk.	Kuppangarai	Morappur	22 to 25 miles.	Inferior burnt ...
(3) Krishnagiri ...	1. Agasipalli	Samalpath... ...	25 miles ...	Durable ...
	2. Chinnameloopalli ...	Pachur	19 „ ...	
	3. Kusubaranganapalli...	Do.	10 „ ...	
	4. Thumniayanapalli ...	Do.	10 „ ...	
12. Coimbatore—				
Karur Taluk ...	1. Athur	Karur	.....	Of large size and durable.
	2. Thoaranakalpath ...	Do.	.....	Do. ...
13. Trichinopoly—				
(1) Trichinopoly Taluk.	1. L. Sholanganallur ...	Elamanoor ...	3 miles ...	Not very hard grey
	2. Thiruvallarai ...	Trichinopoly Fort.*	13 „ ...	Do. ...
	3. Thathamangalam ...	Do. ...	11 „ ...	White porous ...
	4. Irungalore... ...	Do. ...	12 „ ...	Hard white ...
	5. Jachankurichi ...	Do. ...	14 „ ...	Do. ...
	6. Kovandakurichi ...	Do. ...	24 „ ...	Blackish hard ...
	7. Tayanur	Trichinopoly Junc.	5 „ ...	Do. ...

* Places marked thus shown on map on page 13.

of the Stone Quarried, &c., in the several districts of the Madras Presidency—contd.

Cost.	Cost of Carriage to the Railway Station.	Remarks.
Rs. 1-8-0 per cubic foot of cut stones and 0-8-0 per cubic foot of rough stones (including quarrying and delivering at the nearest Railway Station).	.....	
Annas 8 for 3 × 1 × ½ cubic feet at the quarry.	.....	Used for Survey marks only.
Rs. 5 for 100 stones of one cubic foot each.	Rs. 2 per cart-load of 20 stones.	The cost is for undressed stones only.
Rs. 2 per stone of 9 × 3 × ½ cubic foot.	Rs. 4 per stone ...	
Rs. 4 for 100 cubic feet ...	Rs. 1-8-0 per cart-load.	
Do.	Do. ...	
.....	Rs. 2-3-0 per cart-load of 5 cubic feet of stones.	These are the only places in the district which can supply a large quantity of granite in dressed blocks. They are within easy reach of, and have good communication with, Karur.
	Rs. 2-0-6 per cart-load of 5 cubic feet of stones.	
Rs. 5 per ton	Rs. 5 per ton ...	The Cauvery river has to be crossed.
Do.	Do.	
Rs. 3 per ton	Do.	
Rs. 5 per ton	Rs. 4 per ton.	
Do.	Rs. 5 „	
Do.	Rs. 7 „	
Rs. 4½ per ton	Rs. 2 „	

STATEMENT showing the situation of Granite Quarries, the Quality and Cost

District and Taluk.	Village in which Quarry is Situated.	Nearest Railway Station.		Quality of Stone.
		Name.	Its distance from the Quarry.	
Trichinopoly Taluk—*contd.*	8. Pandamangalam ...	Trichinopoly Fort*..	2 Miles ...	Blackish hard ...
	9. Puthur	Do. ...	2 „ ...	Do. ...
	10. K. Abishekapuram	Do. ...	2 „ ...	Do. ...
	11. Piraltugur ...	Do. ...	2 „ ...	Do. ...
	12. Koothappar ...	Tiruvarambur ...	2 „ ...	Do. ...
	13. Nagaveli	Do. ...	6 „ ...	Do. ...
	14. Virappatti ...	Kolathur South ...	21 „ ...	Do. ...
	15. Kolathur (Inam) ...	Kolathur	1½ „ ...	Do. ...
(2) Musiri Taluk ...	1. Nagalapuram ...	Kulitalai	25 „ ...	Do. ...
	2. Neyveli	Elamanur	7 „ ...	Grey not very hard
(3) Kulitalai Taluk ...	1. Sivayam	.....	6 „ ...	White and grey...
	2. Vaiganallur ...	.....	5 „ ...	Do. ...
	3. Togamalai ...	.....	9 „ ...	White ...
(4) Perambalur Taluk.	1. Irur	.....	24 „ ...	Black ...
	2. Naranamangalam...	.....	24 „ ...	Do. ...
	3. Perali	.....	34 „ ...	Do. ...
	4. Vengalam ...	.....	60 „ ...	Do. ...
14. Madura—				
(1) Dindigul Taluk ...	1. Pallapatti... ...	Dindigul* ...	3 „ ...	White granite ...
	2. Seelapadi	Do.	4 „ ...	Do. ...
	3. Sethenayakam path and Alakeriarpath.	Do.	4 „ ...	Do. ...
	4. Adiyanathu ...	Do.	3 „ ...	Do. ...
	5. Mullipadi... ...	Do.	4 „ ...	Do. ...
	6. Thottamuttur ...	Do.	4 „ ...	Do. ...
	7. Balakrishnapuram...	Do.	3 „ ...	Do. ...

* Places marked thus shown on map on page 13.

of the Stone Quarried, &c., in the several districts of the Madras Presidency—contd.

Cost.	Cost of Carriage to the Railway Station.	REMARKS.
Rs. 4½ per ton	Re. 1 per ton.	
Do.	Re. 1 „	
Do.	Rs. 2 „	
Do.	Re. 1 „	
Rs. 5 per ton	Re. 1½ „ ...	Carts cannot go during the rainy season.
Do.	Rs. 3 „	Do. do. do.
Rs. 4 per ton	Rs. 6 „	
Rs. 5 do.	Re. 1 „	
Rs. 7 do.	7 annas per ton.	
Do.	Do.	The Cauvery has to be crossed.
Rs. 3 per ton	Re. 1 per ton.	
Do.	12 annas per ton.	
Rs. 2¼ per ton	Rs. 1¼ per ton.	
4 annas per ton	4 annas per mile.	
Do.	Do.	
Do.	Do.	
Do.	Do.	
Re. 1 for 1 cubic foot of well chiselled stone; 12 annas for 1 cubic foot of rough chiselled stone; and Rs. 1-12-0 for 1 cubic yard of rough stone at the quarries.	2 annas per mile per cart-load.	Granite stones of any size can be got, the cost varies according as the stone is chiselled or rough. There are great facilities for carriage of stones from the Tirupparangundram quarry, at which there is a Railway Station.

STATEMENT showing the situation of Granite Quarries, the Quality and Cost

District and Taluk.	Village in which Quarry is Situated.	Nearest Railway Station,		Quality of Stone.
		Name.	Its distance from the Quarry.	
(2) Madura Taluk ...	1. Tiruparamgundram.	Tiruparamgundram.	.....	Granite in dressed blocks.
	2. Yenamalai ...	Madura	6 miles ...	
	3. Muttupettai ...	Do.	7 „ ...	
15. Tinnivelly—				
Ambasamudram Taluk...	1. Kozhundanamalai...	Sermadevi... ...	2 „ ...	Good granite in dressed blocks.
	2. Kilaambasamudram.	Ambasamudram ...	2 „ ...	
16. Malabar—				
(1) Kurumbranad Taluk	Murat	Badagara	3 „ ...	Suitable kind of granite.
(2) Chirakkal Taluk ...	Mount Deli	.....	.....	
17. South Canara ...	.....	.....	.....	.....
18. The Nilgiris ...	.....	.....	.....	.....

of the Stone Quarried, &c., in the several districts of the Madras Presidency—concld.

Cost.	Cost of Carriage to the Railway Station.	REMARKS.
See Dindigul Taluk	See Dindigul Taluk.	
About Rs. 27 per ton ...	.....	A seigniorage fee has to be paid for quarrying. The cheapest way of transport would probably be to send the stones to Tuticorin and thence to Bombay by sea.
Not more than Rs. 10 per 100 cubic feet at the quarry.	.....	The quarry at Murat is by the side of the Calicut-Azhikkal Railway line, and there is a road and also backwater communication between Murat and the Railway Station (Badagara). It is in private land and is now worked by a Railway Contractor under a lease, the term of which will expire by the 31st March 1907. The quarry at Mount Deli is about 14 miles north of Cannanore. It is on the sea-face of the hill, easily accessible, and would serve the required purpose admirably. Transport by sea to Bombay should be easy and cheap. It is also in private land and is now worked for providing stone for the bridges on the Azhikkal Railway extension. The supply at both the quarries is practically unlimited. As both of them are now worked for railway purposes, the Engineer-in-Chief for Construction, Madras Railway, can give fuller information about them.
.....	.....	Granite rocks exist in several places on the coast line. Dressed stones are not, however, available, as there are very few skilled local stone cutters. When any work requiring the use of dressed stone is undertaken, workmen are usually imported from the East Coast. No opinion can, therefore, be formed about the cost and quality of the stone.
.....	.....	Huge rocks exist in different parts of the district, but there is no quarry worth mentioning which is actually worked. There is, therefore, no reliable information regarding the quality and cost of the stone. Further, the rates of the Nilgiri Railway, which affords the only route, are too prohibitive for making any useful transport.

V. K. RAMANUJACHARIAR,
Secretary.

No. 4043 of 1904.

From

MAJOR W. HAIG,

FIRST ASSISTANT RESIDENT,

Hyderabad,

To

THE SECRETARY,

BOMBAY PORT TRUST,

Bombay

DATED HYDERABAD RESIDENCY, *the 7th June* 1904.

SIR,

With reference to your letter No. 1227, dated 8th March 1904, I am directed to forward a copy of a letter, No. 973, dated the 2nd June 1904, and of its enclosures, from His Highness the Nizam's Minister, regarding granite quarries in His Highness the Nizam's territory.

I have, &c.,

W. E. HUTCHINSON,

for First Assistant Resident.

Copy of letter No. 973, dated 2nd June 1904, from Maharaj Peshkar Sir Kishen Pershad Bahadur, K.C.I.E., Yamin-Us-Saltanat, His Highness the Nizam's Minister, Hyderabad, to the First Assistant Resident, Hyderabad.

Kindly refer to your letter No. 622, dated 15th March 1904, and subsequent reminders regarding information required by the Secretary, Bombay Port Trust, in connection with granite quarries in His Highness' Dominions.

I now forward herewith copy of a note by Mr. J. J. Ottley, Executive Engineer, His Highness' Public Works Department, on granite quarries in His Highness' Dominions, together with a copy of its supplement.

The Secretary, Public Works Department, through whom the notes have been received, states that the variety known as the red granite would probably cost more than the ordinary granite, and that further particulars regarding it can be furnished if needed.

Note on Granite Quarries.

Good granite can be obtained throughout the Telingana Districts of His Highness' territory, but the most convenient for Bombay will be Raichur or about Hyderabad. Good granite is available up to the Godavery river on the Hyderabad-Godaveri Valley Railway, but the break of gauge at Manmad will not be advantageous. The granite obtainable is both laminated and in boulder form, the laminated granite or gneiss is used extensively in Hyderabad Deccan, as the dressing of stone is not expensive, and the quarrying is done by *Wadars* by means of burning. Wood is piled in small quantities on the surface of the rock, and is kept steadily burning for some hours when the upper layer of rock expands sufficiently to produce a separation from the substratum. The extent of the severance is ascertained by a series of taps with the crowbar, the response of which is conclusive to a practised ear. The next operation is to break up this loosened bed of rock into fragments of convenient size by dashing down a large boulder of green stone. By this process the *Wadars* turn out handsome square blocks of stone, the lamina in general use never exceed $1\frac{1}{2}$ feet in thickness. The granite blocks obtainable by cutting or wedging can be made of any size required up to 8 feet cube. The cost of granite at quarry is from Rs. 6 to 12 per 100 c.ft. for laminated stones, and of square blocks of unlaminated stone Rs. 12 to 20 and more per 100 c.ft. The quarrying of block granite is done by steel wedges. A fissure is made artificially by drilling a line of holes at regular short intervals in the direction required, a row of conical steel pointed pins rather large than the holes are set, one in each hole, and struck sharply and simultaneously by hammer, producing a separation. The stone generally separates with a clear even surface.

The colour of the granite obtained in block is darker than the laminated kind. Granite consists of quartz, felspar, mica and hornblende.

For the purposes of the new docks at Bombay, the granite in block is preferable as the blocks are obtainable in greater thickness and of any size required.

The red granite found about Hyderabad is similar in every respect to the boulder granite described by me. The color is due to the felspar being reddish-brown, red, or yellowish pink. The stone used in the building of the fort wall of the City of Hyderabad (as it is obtainable in large quantities in the bed of the Moosi river) is interspersed with the grey granite, and both show no signs of decay. The red granite is, I believe, found near Darur station ; if this information is correct, that place will be the most convenient for trainage to Bombay.

(Sd.) JOHN J. OTTLEY,
Executive Engineer,
16*th May* 1904.

No. 4348 OF 1904.

From

MAJOR W. HAIG,

FIRST ASSISTANT RESIDENT,

Hyderabad,

To

THE SECRETARY,

BOMBAY PORT TRUST,

Bombay.

DATED HYDERABAD RESIDENCY, *the 16th June* 1904.

SIR,

In continuation of my letter No. 4043, dated the 7th June 1904, I am directed to forward a copy of a letter, No. B., dated the 18th May 1904, from the District Engineer, General Branch, Gulburgah, received through His Highness the Nizam's Minister, Hyderabad, containing information regarding granite quarries at Tandur and Nawandgi stations on His Highness the Nizam's Guaranteed State Railway.

I have, &c.,

W. E. HUTCHINSON,

for First Assistant Resident.

Copy of letter No. B., dated 18th May 1904, *from the District Engineer, General Branch, Gulburgah, P. W. Department, to the Superintending Engineer, General Branch, P. W. Department.*

SUBJECT :—*Granite Quarries in the Gulbargah District.*

With reference to your endorsement No. 2759 of 9th May 1904 on P. W. Secretary's No. 4220 of 2nd May 1904 regarding the above noted subject, I have the honor to state that good granite is procurable at Tandur* and Nawandgi* Stations on H. H. the Nizam's Railway. It is not quarried at the latter place, there being no demand for it, but at Tandur the cost per 100 c.ft., delivered at the Railway Station, is H.S. Rs. 7 or British Rs. 6-4-0 at the current rate of exchange. The average contents of each stone is half a cubic foot. The quarries are about 5 miles from the Railway Station.

* Places marked thus shown on map on page 13.

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